C. Drake

PHYSIOLOGICAL RESEARCHES.

PHYSIOLOGICAL RESEARCHES

UPON

LIFE AND DEATH;

BY XAV. BICHAT,

PHYSICIAN OF THE HOTEL-DIEU, PROFESSOR OF ANATOMY, PHYSIOLOGY AND MEDICINE, AND MEMBER OF SEVERAL LEARNED SOCIETIES.

TRANSLATED FROM THE FRENCH

BY TOBIAS WATKINS,

MEMBER OF THE MEDICAL AND CHIRURGICAL FACULTY OF MARYLAND, PHYSICIAN TO THE MARINE HOSPITAL OF BALTIMORE, &c.

FIRST AMERICAN FROM THE SECOND PARIS EDITION.

PRINTED BY SMITH & MAXWELL

PHILADELPHIA.

1809.

DEDICATION.

TO

J. N. HALLÉ,

MEMBER OF THE NATIONAL INSTITUTE OF FRANCE;

AND

PROFESSOR OF THE SCHOOL OF MEDICINE OF PARIS.

XAVIER BICHAT.

ADVERTISEMENT

OF

THE PARIS EDITOR.

It was the intention of the author to have made some important additions to the first part of this new edition. Certain Articles now offered with modifications, would have appeared more complete, and been enriched with several new views: the reader would have found in it a Treatise on Beauty, considered physiologically. In a second volume, these physiological principles would have been applied to Medicine; and the same order which has now been pursued, in considering the functions in their healthy state, would have been adopted to consider them also in a state of disease. The death of the author has deprived the public of these advantages, and compels us again to offer the work in its original state. We conceived it due however, to the memory of citizen Bichat, *to make known those intentions, the fulfilment of which he had already commenced.*

AUTHOR'S PREFACE.

LIFE and death, considered in a general manner, appeared to me a subject susceptible of several views, and many useful experiments. It was this which determined me to undertake the work which I now offer to the Public. I flatter myself the reader will find in it some considerations and facts but little known. Those, however, who have read Aristotle, Buffon, Morgagni, Haller, Bordeu, and others who have written upon this subject, will see that those authors have furnished me with some hints; but they will at the same time know how to distinguish the share which belongs to myself; and I dare hope they will see enough to convince them that whatever is not my own holds but a secondary place in these researches: I must except however the division of life.

Books resemble each other, either in the facts which they contain, or in the style in which they are written. The comparison of facts is easily made; it will show perhaps that many of those which I offer, were wanting to the science. As to the method observed in this work, I have endeavoured equally to avoid placing myself among those who accumulate experiments without correspondent reasoning, and among those who produce arguments unfounded in experiment.

In the present state of physiology, it appeared to me the most judicious plan to connect the experimental method of Haller and Spallanzani, with the grand and philosophic views of Bordeu; if I have failed in attaining this object, it has not been through want of knowing how to appreciate it.

I have extended some divisions already announced in my Treatise on the Membranes, and have again offered them as my own, notwithstanding they have been attributed to Buffon, Bordeu and Grimaud. These authors are so well known, that I considered it unnecessary to quote them with critical exactness. For this reason also I have not attempted to remove the doubts before expressed on some anatomical facts published by me. I shall merely refer those who have entertained these doubts to an inspection of the dead body. For those who gave rise to them, such an inspection is unnecessary: they cannot have forgotten that I have dissected with them, and have demonstrated to them what they now accuse me with having established upon unfounded conjecture.

Finally, I have been cautious, in this work as well as in my former one, not to rely too much upon myself, assured that a thousand circumstances may escape the notice of one and present themselves to another. My experiments have been made often in the presence of a great number, and always with several of the students who attended my lectures. Citizen Hallé has sacrificed much time in repeating the most important; and citizen Duméril has been equally polite. If they should excite the interest of any other lovers of science, my assistance shall be readily afforded.

AN ANALYTICAL TABLE OF CONTENTS.

PART I.

PHYSIOLOGICAL RESEARCHES UPON LIFE.

ARTICLE I.

General division of life.

ARTICLE II.

General differences of the two lives with respect to the external forms of their respective organs.

ARTICLE III.

General differences of the two lives with respect to the mode of action of their respective organs.

ARTICLE IV.

General differences of the two lives with respect to the duration of their action.

ARTICLE V.

General differences of the two lives with respect to habit.

ARTICLE VI.

General differences of the two lives morally considered.

ARTICLE VII.

General differences of the two lives with respect to their vital powers.

ARTICLE VIII.

Of the origin and development of animal life.

ARTICLE IX.

Of the origin and development of organic life.

ARTICLE III.

Of the influence which the death of the heart exercises upon that of the lungs.

ARTICLE IV.

Of the influence of the death of the heart upon all the organs.

I have passed over in silence the influence of the death of the heart with black blood upon that of the organs, because it is extremely rare that death commences by that.

ARTICLE V.

Of the influence which the death of the heart exercises upon general death.

ARTICLE VI.

Of the influence which the death of the lungs exercises upon that of the heart.

ARTICLE XIII.

Of the influence which the death of the brain exercises on general death.

RESEARCHES, &c.

PART I.

ARTICLE I.

GENERAL DIVISION OF LIFE.

THE definition of life is to be sought for in abstract considerations; it will be found, I believe, in this general perception: *life is the totality of those functions which resist death.*

Such is in fact the mode of existence of living bodies, that every thing which surrounds them tends to their destruction. Inorganic bodies act upon them incessantly; they themselves exercise a continual action, the one upon the other; and would necessarily soon be destroyed, did they not possess a permanent principle of reaction. This principle is life; not understood in its nature, it can be known only by its phenomena: the most general of which is that constant alternation of action on the part of external bodies, and of reaction on the part of the living body, the proportions of which alternation vary according to age.

There is a superabundance of life in the infant, because the reaction is greater than the action. In the adult, an

equilibrium is established, and thus this vital turgescence disappears. The reaction of the internal principle is diminished in old age, while the action of external bodies remains the same; thus life languishes and advances insensibly towards that natural term, which must happen when all proportion has ceased.

The measure of life then, in general, is the difference which exists between the effort of external powers, and of internal resistance. The excess of the former announces its weakness; the predominance of the latter is an indication of its strength.

SECTION I.

Division of Life into Animal and Organic.

Such is life considered in the whole; examined more minutely, it offers to our view two remarkable modifications. The one is common to vegetable and animal, the other is peculiar to the last. Let us cast our eyes, for example, on an individual of each of these living kingdoms: we shall see that the one exists only within itself, having no other relation to what surrounds it, than as it respects nutrition, that it springs up, flourishes, and dies, in the spot which received its germe; that the other has, in addition to this *internal life* which it enjoys in a higher degree, an *external life* which establishes numerous relations between it and surrounding objects, that its existence is entwined with that of every other being, that it avoids or approaches these according to its fears or wants, and thus appears to appropriate every thing in nature to its exclusive use.

It may be said that the vegetable is the rough sketch, the *canvas* of the animal; and that to form this last, no-

thing more is necessary than to display upon this canvas the external organs proper to establish its different relations.

It hence results that the functions of the animal form two very distinct classes. The one is composed of a continual succession of assimilation and excretion; by these it is incessantly converting to its own substance the particles of surrounding bodies, and again ejecting these particles when they have become heterogeneous. It lives within itself only, by this class of functions; by the other, it exists, as it were, *out of itself:* it is the inhabitant of the world, and not, like the vegetable, of the spot which gave it birth. It feels and perceives what surrounds it, reflects its sensations, moves voluntarily according to their influence, and most generally has the power of communicating by voice, its desires and its fears, its pleasures or its pains.

The assemblage of the functions of the first class, I call *organic life*, because all organized beings, vegetable or animal, enjoy it in a greater or less degree, and because organic texture is the only condition necessary to its exercise. The united functions of the second class form *animal life*, thus called, because it is the exclusive attribute of the animal kingdom.

Generation does not enter into the series of phenomena of these two lives, they having relation to the individual, while that regards the species only: nor is it connected, except indirectly, to most of the other functions. It begins its exercise only after the others have been long in action, and is extinct long before they cease to act. In the greater part of animals its periods of activity are separated by long intervals of rest; in man, in whom its remissions are less durable, its relations to the functions are not more numerous. The subtraction of those organs which are its agents, is almost always followed by a general increase of nutri-

tion. The eunuch possesses less vital energy; but the phenomena of life in him, are developed in greater plenitude. Let us, however, leave the consideration of those laws which *give us* existence, and take up those only which *maintain* it: we shall recur to the former hereafter.

SECTION II.

Subdivision of each of the lives, ANIMAL *and* ORGANIC, *into two orders of functions.*

EACH of the two lives, animal and organic, is made up of two orders of functions, which succeed, and are connected to, each other in an inverse ratio.

In animal life the first order is established from the exterior of the body towards the brain, and the second, from this organ towards those of locomotion and voice. The impression of objects is made successively upon the senses, the nerves, and the brain. The first *receive*, the second *transmit*, and the last *perceives* the impression, which being thus received, transmitted, and perceived, constitutes our sensations.

The animal is almost passive in the first order of functions; he becomes active in the second, which results,—from the successive actions of the brain—whence springs volition, the consequence of sensations, from the nerves which transmit this volition, and from the organs of locomotion and voice—the agents of its execution. External bodies act upon the animal by the first order of functions; it reacts upon them by the second.

There exists, in general, a rigorous proportion between these two orders; where the one is plainly marked, the other also is strongly developed. In a series of animals, it will be

found, that the one which possesses the greatest share of sensibility, enjoys also the greatest variety of motions. The age of lively sensations, is that also of vivacity of motion; in sleep, when the first order is suspended, the second ceases, or is only irregularly exercised. Those blind of one eye, who only half see what surrounds them, connect their different motions with a tardiness and caution which would soon be lost, if their external communications were increased.

A double action is exercised also in organic life; the one is incessantly *composing*, while the other *decomposes* the animal. Such, in fact, (as the ancients and after them some moderns have observed) is his mode of existence, that what he was at one period he ceases to be at another; his organization remains the same, but his *elements* are continually changing. The nutritive particles alternately absorbed and ejected, pass from the animal to the plant, thence to the brute, and so on again to the animal.

Organic life is well suited to this continual circulation of matter. One order of functions assimilates to the animal, those substances which are to nourish him; another carries off, what has become heterogeneous to, after having for some time made a part of, his organization.

The first, which is the order of *assimilation*, results from digestion, circulation, respiration, and nutrition. Every particle foreign to the body, before it can become one of its elements, receives the influence of these four functions.

When it has thus furnished its portion to the formation of our organs, *absorption* takes it up and conveys it into the circulatory stream, whence it is thrown out by pulmonary or cutaneous exhalation, and the various secretions by which all the fluids are ejected.

Absorption, circulation, exhalation, and secretion form then, the second order of functions of organic life, or the order of *dis-assimilation*.

Hence it follows that the sanguineous is the *mean* system, the *centre* of organic life, as the brain is of animal life, where those particles to be assimilated, and those, which having already undergone assimilation, are destined to be thrown out, confusedly circulate; so that the blood is composed of two parts, the one *recrementitious*, produced by the aliments and the exhausted materials of nutrition, and the other *excrementitious*, which is the rubbage, the residuum of all our organs, and which supplies the secretions and external exhalations. These last functions, however, sometimes serve also to throw out certain digestive products, which have had no concurrence in nourishing the parts. This may be seen in the urine and sweat, after copious potations. The skin and kidneys are then excretory organs, not of nutrition but of digestion. This may be observed still more clearly in the production of milk, a fluid manifestly formed out of that portion of the blood, which has not been assimilated by the nutritive process.

There is not the same conformity between the two orders of functions of organic life, as between those of animal life; the enervation of the first does not necessarily bring on a diminution of the second: hence leanness, marasmus, &c. states of the body in which assimilation in part ceases, *dis-assimilation* is exercised uninterruptedly.

These grand differences between the two lives of the animal, and those not less strongly marked limits which separate the two orders of phenomena of which each is the *assemblage*, appear to me to offer to the physiologist, the only real division which can be established between the functions.

Artificial methods we shall leave to the other sciences; let us pursue the order of the phenomena, connect the ideas we form of them, and we shall then see, that the greater

part of physiological divisions offer only uncertain foundations to him who would raise upon them the edifice of science.

I shall not take notice of those divisions here; the best means of pointing out their insufficiency will be to prove the validity of the system which I have adopted. Let us now go over in detail the grand differences which separate the animal living *from without*, from the animal existing *within itself* in an alternate round of assimilation and excretion.

ARTICLE II.

GENERAL DIFFERENCES OF THE TWO LIVES WITH RESPECT TO THE EXTERNAL FORMS OF THEIR RESPECTIVE ORGANS.

THE most essential of the differences which distinguish the organs of animal life, from those of organic life, are the symmetry of the one, and the irregularity of the other. Some animals offer exceptions to this character, particularly as to animal life: such as among fish, soles, turbots, &c. different species of the *non-vertebral* animals, &c. &c. but it is exactly traced in man, as well as in those animals which approximate to him in perfection. In these only I shall examine it; to be satisfied of it a bare inspection is sufficient.

SECTION I.

Symmetry of external forms in ~~organic~~ Animal life.

Two perfectly similar globes receive the impression of the light. Sound and odours have each also their double analogous organ. A single membrane is the seat of savours, but in it the median line is manifest; and each division marked by it resembles that of the opposite side. The skin does not always present to us visible traces of this line, but it may be supposed present throughout. Nature, in forgetting, if it may be thus said, to draw it, has placed from space to space, striking indications of its course. The fissures at the extremities of the nose and chin, and in the middle of the lips, the umbilicus, the *raphe* of the perinæum, the projections of the spinous *apophyses*, and the middle hollow in the posterior part of the neck form the principal points of these indications.

The nerves which transmit the impression made by sounds, such as the optic, the acoustic, the lingual and olfactory are evidently assembled in symmetrical pairs.

The brain, the organ upon which the impression is received, is remarkable for its regular form; its pairs resemble each other on every side, such as the bed of the optic nerves, the *corpora striata*, the *hippocampi*, and the *corpora fimbriata*. Those parts not in pairs are all symmetrically divided by the median line, of which several afford visible traces, as the *corpus callosus*, the *fornix*, *tuber annulare*, &c.

The nerves which transmit the volitions of the brain to the agents of locomotion and voice, the locomotive organs formed in a great measure from the muscular and osseous systems, the larynx and its accessories, the double agents

of the execution of these volitions, have all a regularity, a symmetry which are never found wanting.

Such, in fact, is the truth of this character, that the muscles and nerves cease to become regular, when they no longer belong to animal life. The heart, the muscular fibres of the intestines, &c. are a proof of it, with respect to the muscles; as to the nerves, the great sympathetic destined throughout to internal life, presents in the greater part of its branches an irregular distribution.

The *solar plexus*, the mesenteric, hypogastric, splenic, &c. afford examples of it.

We must then, I think, form this evident conclusion, that symmetry is the essential character of the organs of the animal life of man.

SECTION II.

Irregularity of external forms in organic life.

If we pass now to the viscera of organic life we shall see that a diametrically opposite character is applicable to them. In the digestive system the stomach, the intestines, the spleen, liver, &c. are all irregularly disposed.

In the circulatory system, the heart, the large vessels, such as the aorta, the venæ cavæ, the azygos, the vena porta, and the *arteria innominata* offer no trace of symmetry. In the vessels of the limbs, continual varieties are observed, and what is remarkable, in these varieties the disposition of one side, never affects that of the other.

The organs of respiration appear at first sight to be perfectly regular; if it is observed, however, that the right bronchia differs from the left in length, diameter, and direction; that three lobes compose one of the lungs, and

that the other is made up of two only; that there is a manifest inequality of volume between them; that the two divisions of the pulmonary artery resemble each other neither in their course nor in their diameter; that the mediastinum upon which runs the median line deviates perceptibly to the left, we shall see that the symmetry was but apparent, and that the common law suffers no exception.

The organs of exhalation and absorption, the serous membranes, the thoracic canal, the great right lymphatic vessel, and the secondary absorbents of all the parts have throughout an unequal and irregular distribution.

In the glandulous system, we see the cryptæ or mucous follicles everywhere disseminated without order, under their respective membranes. The pancreas, liver, and salivary glands even, though apparently more symmetrical, are not found exactly subjected to the median line. The kidneys differ from each other in their position, the number of their lobes, (in the infant) the length and size of their artery and their vein, and above all, in their frequent varieties.

These numerous considerations lead us evidently to a conclusion the reverse of the preceding, that is to say, that the peculiar attribute of the organs of internal life, is the irregularity of their external forms.

SECTION III.

Consequences which result from the difference of external forms in the organs of the two lives.

It follows from the view which has been taken, that animal life is, as it were, double, that its phenomena executed at the same time on two sides, form in each of those

sides an independent system, that there is, if I may thus express myself, a *right* life and a *left* life, that the one may exist while the action of the other ceases, and that they are most probably destined reciprocally to supply each other.

It is this which happens in those common sickly affections, where the sensibility and animal mobility, weakened or even entirely destroyed, in one of the symmetrical halves of the body, lose all connexion with what surrounds us; when the man is, on one side, scarcely more than vegetable, while, on the other, he retains all his right of animality in the remaining sensation and motion. These partial paralyses in which the median line is the end and origin of the faculty of feeling and moving, certainly cannot be so regularly observed in animals, which, like the oyster, have an irregular exterior.

Organic life, on the contrary, makes one uniform system where all is coordinate, where the functions of one side cannot be interrupted, without necessarily producing disorder in those of the other. The liver diseased on the left influences the state of the stomach, on the right; if the colon of one side ceases to act, that of the other cannot continue its action; the same blow which stops the circulation in the great venous truncs and the right portion of the heart, destroys it also in the left portion and the great arterial truncs of this side, &c. Whence it follows, that, supposing all the organs of internal life of the one side to cease their functions, those of the opposite side necessarily remain inactive and death must ensue.

This assertion, however, is only general; it holds good only in the *totality* of organic life, and not in its separate phenomena; some, in fact, are double and may supply each other, of which the kidneys and lungs afford an example.

I shall not search for the cause of this remarkable difference which in man and some other animals, distinguish

the organs of the two lives; I shall merely observe that it enters essentially into the order of their phenomena, that the perfection of the animal functions should so depend upon the symmetry of their respective organs, that whatever should disturb this symmetry should have more or less influence upon the functions.

Hence no doubt arises the other difference between the organs of the two lives, namely, that Nature more rarely indulges herself in varieties of conformation, in animal, than in organic life. Grimaud has made this observation, without telling the principle, upon which the fact which it presents to us is founded.

The frequent variations of form, size, position, and direction of the internal organs, as the spleen, liver, stomach, kidneys, salivary organs, &c. cannot have escaped the remark of any one accustomed to dissections. So common indeed are these varieties in the vascular system, that scarce two subjects offer exactly the same disposition to the knife of the anatomist. Who does not know that the organs of absorption, the lymphatic glands in particular, are rarely found subjected to the same proportion of number, volume, &c. in two individuals? that the mucous glands have never a fixed and analogous position?

Nor is each system when separately examined only, found thus subject to frequent aberrations, but the *totality* even, of the organs of internal life, is sometimes found reversed from their natural order. During the last year, a child was brought to my amphitheatre, who had lived several years with a general confusion of the viscera of digestion, circulation, respiration, and secretion. On the right were found the stomach, spleen, the arch of the colon, the *apex* of the heart, the aorta, the two lobed lung, &c. On the left were seen the liver, the cæcum, the base of the heart, the venæ cavæ, the azygos, the three lobed lung, &c.

All the organs placed under the median line, such as the mediastinum, mesentery, duodenum, pancreas, and the division of the *bronchiæ*, were also reversed from their proper order. Several authors have spoken of these disorders of the viscera, but I know no example of it so complete as the present.

Let us now throw our eyes upon the organs of animal life, the senses, nerves, brain, voluntary muscles, larynx, &c.; all here is exact, precise, and rigorously determinate in form, size, and position. Varieties of conformation, in these, are seldom or never seen; if they should exist, the functions are disturbed: while they remain the same in organic life, notwithstanding the different alterations of the parts.

This difference between the organs of the two lives, is evidently in proportion to the symmetry of such as the slightest change of conformation disturbs, and to the irregularity of others with which the different changes are closely connected.

In animal life, the play of each organ is immediately dependant upon its resemblance with its fellow of the opposite side, if it be double, or to the uniformity of conformation in its two symmetrical halves, if it be simple. Hence may be conceived the influence which organic changes have upon the derangement of the functions.

But this will become more evident, when I shall have pointed out the connexions which exist between the symmetry or irregularity of the organs, and the harmony or discordance of the functions.

ARTICLE III.

GENERAL DIFFERENCE OF THE TWO LIVES WITH RESPECT TO THE MODE OF ACTION OF THEIR RESPECTIVE ORGANS.

HARMONY is to the *functions* of the organs what symmetry is to their *conformation;* it supposes a perfect equality of force and action, as symmetry indicates an exact analogy in the external forms and internal structure. It is a consequence of symmetry; for two parts essentially alike in their structure, cannot be different in their mode of acting. This plain reasoning will lead us to the general datum, that harmony is the character of the external functions, and that discord is, on the contrary, the attribute of the organic functions; but upon this head it will be necessary to go into more ample detail.

SECTION I.

Of the harmony of action in animal life.

WE have seen that external life resulted from the successive actions of the senses, nerves, brain, and locomotive and vocal organs. Let us now consider the harmony of action, in each of these grand divisions.

The precision of our sensations appears to be so much the more perfect, as there happens to exist a more exact resemblance between the two impressions of which each is the assemblage. We see imperfectly when one of the eyes, better constituted and stronger than the other, is

more vigorously affected and transmits to the brain a stronger image. It is to avoid this confusion, that one eye is shut when the action of the other is artificially augmented by a convex glass: the glass destroys the harmony of the two organs, we use but the one, that there may be no discordance. What a glass produces artificially, the *strabismus* affords a natural example of. We squint, says Buffon, because we turn the weakest eye from the object upon which the strongest is fixed, and thereby avoid the confusion which would otherwise arise from the perception of two unequal images.

I know that many other causes concur to produce this affection, but the reality of this cannot be disputed. I know also that each eye has the power of acting separately in different animals; that two different images are transmitted at the same time by the two eyes of certain species; but this does not hinder that the two impressions which they transmit to the brain be analagous, when these organs unite their action upon the same object. A uniform judgment becomes the result: now how could this judgment be formed with correctness if the same body presented itself at the same time with a lively and a weak colouring, according as it should be painted upon the one or the other retina?

What we have said of the eye may be applied also to the ear. If in the two sensations which compose the hearing, the one is received by an organ stronger and better developed, it will leave a clearer and more distinct impression; the brain differently affected by each, would be the seat of an imperfect perception only. It is this which constitutes a false ear. Why is one man painfully affected by a dissonance which is not perceived by another? It is because in the former, the two perceptions of the same sound

are confounded in one—this is precise, and distinguishes the slightest fault in the song, while in the latter the two ears offer different sensations, the perception is habitually confused and cannot estimate the defect of harmony. It is for the same reason that you see one man in the dance regulate his steps to the music of the orchestra, while another, on the contrary, is in constant discord with it.

Buffon has confined to the eye and ear, his considerations on the harmony of action. Let us pursue the examination in animal life.

In *smell*, as in the other senses, two impressions must be distinguished, the one *primitive* and belonging to the organ, the other *consecutive* and affecting the sensorium: the latter may vary while the former remains the same. By certain odours some persons are driven from a place to which others are attracted; this is not because the affection of the pituitary is different, but because the mind attaches different sensations to the same impression, so that the variety of results in these, is no indication of any in their principle.

But sometimes the impression made upon the pituitary, differs from what it really ought to be for the perfection of the sensation. Two dogs pursue the same game; the one never loses the scent, follows it in all its windings and turnings; the other follows also, but stops often, loses the foot, as it is called, hesitates and endeavours to recover it, runs on and again stops. The first of these dogs receives a lively impression from the odorous emanations: while they only confusedly affect the organ of the second. Is not this confusion occasioned by the inequality of action of the two nostrils, by the superior organization of the one, and by the weakness of the other? The following observations appear to prove it.

In a *coryza* which affects but one nostril, if both remain open the smell is confused; close that of the affected side and it will become distinct. A *polypus* on one side weakens the action of the correspondent pituitary, while that of the other remains unchanged: hence, as in the preceding case, the defect of harmony between the two organs, and the consequent confusion in the perception of odours. Most of these affections of one nostril separately, have similar results, and may be temporarily corrected in the manner I have pointed out; and why? because by rendering inactive one of the pituitaries its discordance of action with the other is made to cease.

We may conclude from this, that, since every accidental cause which destroys the harmony of the functions of the organs, renders the perception of odours confused, it is probable that where this perception is *naturally* incorrect, there is a *natural inequality* of conformation and consequently of strength in the nostrils.

The same also may be said of the *taste:* the tongue is often affected on one side only, with paralysis and spasm. The median line sometimes divides the insensible portion from that part which still preserves its sensibility. Why should not the same happen in the whole which takes place in a part? Why should not one of the sides, in preserving the faculty of perceiving savours, enjoy it in a less degree than the other?* Now in this case it is easy to conceive

* "*Pourquoi l'un des côtés, en conservant la faculté de percevoir les saveurs n'en jouiroit-il pas à un moindre degré que l'autre ?*" The meaning of this interrogatory, as it thus stands, is very obscure; the inference which the author wished should be deduced from it, however, appears to be, that, as only *one side* of the tongue may be affected with *paralysis*, which is offered as a proof that *taste* is composed of *two distinct* sensations, the remaining side, or that portion of the tongue not affected by the paralysis must communicate to us but a very imperfect idea of the impressions made upon it, or, in other words, a very inaccurate taste. T.

that the taste will be irregular and confused, because one precise perception cannot succeed to two unequal sensations which have the same object. Who does not know that substances which by some are thought perfectly insipid, afford to others a thousand subtile causes of painful or agreeable sensations?

The perfection of *touch*, like that of the other senses, is essentially connected to the uniformity of action of the two symmetrical halves of the body, of the two hands particularly. Let us suppose a blind man born with one hand regularly organized, while the other deprived of the antagonist motions of the thumb and fingers should form a rough, immovable surface; such a man would with great difficulty acquire notions of size, figure, direction, &c., because one identical sensation would not spring from the successive application of the two hands upon the same body. Let both touch a small sphere, for example; the one exactly embracing the extremities of all its diameters, would create the idea of rotundity; the other which could come in contact with it only at particular points, would give a very different sensation. Suspended between these two judgments, the blind man would know not which to form; he might even form a *double* judgment corresponding to the double sensation created by the external form of the same body as presented to the two hands. His ideas would be more correct if he condemned one hand to inaction, as he who squints turns the weakest eye from the object to avoid that confusion, the inevitable consequence of a diversity of sensations. The hands then reciprocally assist each other; the one *confirms* the ideas which the other has *created:* hence the necessary uniformity of their conformation.

The hands are not the only agents of touch; the folds of the forearm, of the axilla, and of the groin, the concavity of the foot, &c. may furnish us with real though less per-

fect foundations for our judgment of external forms. Now let us suppose one half of the body to be differently disposed from the other, the same uncertainty in perception would be the result.

We conclude from what has been said, that in the whole apparatus of the external sensitive system, the harmony of action of two symmetrical organs, or of the two similar divisions of the same organ, is an essential condition to the perfection of sensation.

The external senses are the natural exciters of the brain, the functions of which, in animal life, constantly succeed theirs, and which would languish in perpetual inaction, did it not meet with, in them, the principle of its activity. Sensations are immediately derived from perception, memory, and imagination, and from these the judgment. Now it is easy to prove that these different functions, commonly designated by the term of *internal senses*, are governed by the same law in their exercise as the external senses, and that like these they advance so much the nearer to perfection, as there is more harmony between the two symmetrical portions of the organ in which they hold their seat.

Let us suppose, for example, one of the hemispheres to be more strongly organized and better developed at all points than the other, and therefore susceptible of being more vigorously affected; then, I say, the perception will be confused; for the brain is to the mind, what the senses are to the brain; it transmits to the mind the shock received from the senses, in like manner as these last communicate to *it* the impressions made upon *them* by surrounding bodies. Now if a defect of harmony in the external sensitive system can disturb the perceptions of the brain, why should not the mind perceive confusedly when the two hemispheres, unequal in point of force, do not combine in one, the double impression which they receive?

In memory (the faculty of reproducing former sensations) and in imagination (the faculty of creating new ones) each hemisphere appears to create or to reproduce a sensation. If both are not perfectly correspondent, the perception of the mind which is to combine them, will be imperfect and irregular. Now, there must certainly be an inequality in the two sensations, if it exists in the two hemispheres which are the *seats* of these sensations.

Perception, memory, and imagination are the ordinary bases of the judgment: if the former are confused, how will the latter be distinct?

We have *supposed* an inequality of action in the two hemispheres, to prove that a defect of precision in the intellectual functions, must be the consequence; but what we have taken hitherto as supposition only, becomes reality in a multitude of instances. What is more common than to see produced from a compression on one of the hemispheres, by blood, by extravasated pus, a depressed bone or an exostosis on the internal surface of the cranium, numerous alterations in memory, perception, imagination, and judgment?

Even after every sign of actual compression has disappeared, if, still under the influence of that which it has just experienced, one side of the brain should remain enfeebled, are not these alterations prolonged in the same proportion? Are not various alienations of the mind the unhappy consequences? If both sides should be equally affected, the judgment would be weaker, but it would be more exact. It is in this way only that we can explain a fact often observed, that a blow upon one of the lateral regions of the head has re-established the intellectual functions which had been long disturbed in consequence of a prior blow received upon the opposite region.

I trust I have made it apparent that the intellectual functions must be disturbed, by an inequality of action in the

two hemispheres: I have shown several cases where this disturbance was the evident effect of such an inequality. We here *see* the cause and the effect; and in those cases where the latter only is apparent, will not analogy guide us to the former? Where the judgment is habitually incorrect, where all the ideas fail in precision, are we not led to believe that there is a defect of harmony between the two sides of the brain? We see askance if Nature has not given equal strength to the two eyes. We perceive and we judge in like manner if the two hemispheres are naturally discordant: the soundest judgment and most correct wit suppose the completest harmony between them. What shades are there in the operations of the understanding! and do not these shades correspond to as many varieties in the respective powers of the two halves of the brain? If we could squint with this organ as with the eyes, that is, receive external impressions but upon one hemisphere, and employ only one side of the brain to form our determinations and judgments, we should then be able to govern our intellectual operations with precision; but such a faculty does not exist.

Let us pursue the examination of the harmony of action, in the system of animal life. To the functions of the brain succeed locomotion and voice; the former appears at first sight to be an exception to the general law of harmony. Examine the two vertical halves of the body; you will see the one constantly superior to the other in the extent, number, and facility, of the motions it executes. The right side, it is well known, has this advantage over the left.

To comprehend the reason of this difference, let us take into view the *strength* and *agility* of every motion. *Strength* depends on the perfection of organization, the energy of nutrition, and the plenitude of life, of each muscle; *agility* is the result of habit and frequent exercise.

Let us in the next place take notice that the discordance of the locomotive organs is observed not in the *strength* but in the *agility* of the motions. There is a perfect equality of volume, number of fibres and nerves, of both the limbs, superior as well as inferior; in the vascular system there is scarcely any difference. It follows then that this discordance is seldom or never in Nature, but is the manifest consequence of our social habits, which, by multiplying the motions of one side, augment their dexterity without adding much to their strength.

Such are the wants of society that it is necessary a certain number of general motions should be executed by all in the same direction, to the end that they may be understood by all. It has been agreed that this direction should be from left to right. The letters which make up the writings of most people are directed in this way. This circumstance imposes the necessity of employing the right hand which is better adapted than the left to the formation of letters in this direction, as the latter would suit the opposite mode of writing infinitely better, of which the slightest experiment will be sufficient to convince oneself.

The direction of letters from left to right renders it necessary to give the same course to the eyes; the habit of reading thus, begets that of examining most objects after the same manner.

Necessity determines armies to employ theright hand to seize their arms; harmony which is found to govern the dances of the most savage people, demands an accord in the legs, which they maintain by using the right for all their principal motions. To these examples, numerous others might be added.

These general motions, which, being agreed upon by all in the social order, would, if not executed by all after the same manner, destroy the harmony of a number of actions;

these motions, I say, compel us, from the unavoidable influence of habit, to employ for our particular necessities the limbs which they put into exercise. Now, these being of the right side, it follows that the members of this side are in constant activity whether for the execution of those motions exacted by the social compact or for our own proper wants.

As the habit of acting perfects the action, the cause of this excess of agility in the right members may be easily conceived. It will be seen that it is not *primitive*, but insensibly produced by custom.

This remarkable difference in the two symmetrical halves of the body is not then, naturally, an exception to the general law of harmony of action in the external functions. This is so true that the *totality* of our motions is so much the more correct, as there is less difference in the agility of the right and left muscles. Why do certain animals skip with such dexterity over rocks, where the smallest deviation would plunge them into an abyss, or why do they run with such wonderful precision over forms scarce equal in size to the extremities of their limbs? or why is the walk of the most clumsy animal never attended with those false steps so common in the progression of man? It is because in them there being scarcely any difference in the locomotive organs, they are in constant harmony of action.

The man who is most dextrous in the whole of his motions, is the least so in the particular motions of the right side: for, as I shall prove elsewhere, the perfection of one part is never acquired but at the expense of all the others. A child, who should be brought up to use all his limbs equally, would possess a degree of precision in his general motions which it would be afterwards difficult to acquire in the particular motions of the right side, such as those required for writing, fencing, &c.

I believe, however, that some natural circumstances have an influence on the choice of the direction of those general motions which social habits call for, such are, the slight excess of diameter of the right subclavian, that sensation of lassitude which accompanies digestion and which, more sensible on the left side on account of the stomach, compels us to use during this time the muscles of the opposite side, and lastly, that natural instinct which in affecting emotions impels us to lay the hand upon the heart, to which the right is much more easily directed than the left. But these causes are very inconsiderable compared to the disproportion in the motions of the two symmetrical halves of the body, and for this reason it is always correct to attribute their discordance to our social habits, and to believe that Nature originally destined them to harmony of action.

The voice, together with locomotion, is the last act of animal life in the natural order of its functions. Most physiologists, particularly Haller, have attributed its defect of harmony, 1st, to a discordance of the two symmetrical halves of the *larynx;* and, 2ndly, to an inequality of strength in the muscles which move the *arytenoides*, of action in the nerves which go to each side of this organ, and of the reflection of sounds in the two nostrils and in the right and left sinuses. A false voice, doubtless, often depends upon the ear: when we hear falsely we sing after the same manner; but when the correctness of the hearing is in exact proportion to the defect of precision in the sounds, then the cause of it is certainly in the larynx.

The most harmonious voice, therefore, is that produced by the two divisions of the *larynx* in an equal degree, where the vibrations of one side, exactly corresponding in number, force, and duration with those of the opposite side, are combined with them to produce the same sound;

in like manner, is the most agreeable singing produced by two voices which resemble each other exactly in capacity, tone, and inflexion.

From the numerous considerations which I have presented, this general inference may be drawn, that one of the essential principles of animal life, is the harmony of action of two analogous parts, or of the two sides of a simple part, which concur to produce the same effect. The connexion which exists between harmony of action (the character of the functions) and symmetry of form (the attribute of the organs of animal life) may be easily seen without being particularly pointed out.

Before we finish this section it may be proper to observe that, in explaining the different derangements which result from a defect of harmony in the organs, in animal life, I have assigned but one cause; whereas a thousand circumstances, besides the discordance of the two hemispheres of the brain, may disturb the operations of the judgment, memory, &c.

SECTION II.

Discordance of action in organic life.

Let us in the next place consider the phenomena of organic life; we shall find that harmony exercises no influence over them. If one kidney, stronger than its fellow, secretes more urine: or one lung, better developed, admits, in a given time, more venous, and sends out more arterial blood; or there is more organic force in the left, than in the right salivary glands; no alteration is produced in the exercise of the respective functions of these organs. If a slight obstruction takes place in one side of the liver, spleen,

or pancreas, the healthy portion supplies the deficiency, and the function is not interrupted. Circulation is carried on, in spite of the frequent varieties in the vascular system of the two sides of the body, whether these varieties exist naturally, or are the effect of accidental obliterations of the great vessels, as in aneurism.

Hence those numerous irregularities of structure, those defects of conformation which, as I have said, are observed in organic life, without producing any discordance in the functions. And hence, the almost continual succession of modifications which, alternately enlarging and abridging the circle of these functions, never leaves them in a fixed state. The vital powers and the stimuli which excite them to action, continually varying in the stomach, kidneys, liver, lungs, heart, &c., necessarily produce an instability in their phenomena. A thousand causes may at every moment double, triple the activity of the circulation and respiration, increase or diminish the secretions of bile, urine, and saliva, or suspend or accelerate the nutrition of a part; hunger, food, sleep, motion, rest, the passions, &c. create such mobility in the functions, that they daily undergo numerous changes in their degrees of strength or weakness.

In animal life, on the contrary, all is uniform, constant, and regular. Neither the vital powers of the senses, nor indeed the internal powers can undergo these alternations of modification; at least not in so high a degree. Indeed, an habitual affinity unites them to the physical powers which govern external bodies: now, these latter remaining the same in their variations, each of these variations would destroy the affinity, and the functions would cease.*

* The reader may be better enabled to understand this by taking the trouble to refer to the second Section of the first Article, wherein the different relations between internal and external bodies are more fully explained. T.

Moreover, if this susceptibility of change which characterises organic life, was a quality also of the sensations, it might be, in like sort, of perception, memory, imagination, and judgment, and consequently of the will. What then would be man! hurried on by a thousand opposing motions, the perpetual sport of all that surrounded him, he would alternately sink, in his existence, to the nature of the brute, or rise superior to himself, soar to the highest pinnacle of excellence, or fall to the lowest abyss of wretchedness.

ARTICLE IV.

GENERAL DIFFERENCES OF THE TWO LIVES WITH RESPECT TO THE DURATION OF THEIR ACTION.

I HAVE just explained one of the grand characters which distinguish the phenomena of animal life from those of organic life. That which we are about to examine, is of no less importance; it consists in the *periodical intermissions* of the *external* functions, and the *uninterrupted continuance* of the *internal* functions.

SECTION I.

Of the continuance of action in organic life.

The cause which suspends respiration and circulation, suspends also, and even destroys life, though its application be protracted ever so short a time. All the secretions go on without interruption, and if any periods of remission are observed in them, as in the bile when not engaged in the process of digestion, and in the saliva when not employed for the purpose of mastication, &c., these periods have relation only to the intenseness and not to the entire exercise of the function. Exhalation and absorption succeed each other without ceasing; nutrition is never in a state of inactivity; the double operation of assimilation and *dis-assimilation* from which it results, has no end but with life.

In this continued catination of organic phenomena, each function is in a state of immediate dependance upon those which precede it. Circulation, the centre of all, is always immediately connected to their exercise. If it is disturbed, the others languish; they cease when the blood is motionless. In like manner are the numerous wheels of a clock stopped, when the motion of the pendulum is arrested. Not only is the general action of organic life connected to the particular action of the heart, but each function is moreover separately united to all the rest. Without secretion there could be no digestion, without exhalation no absorption, and no nutrition without digestion. We may then, I think, offer as the general character of organic functions, their continuance of action and their mutual dependance upon each other.

SECTION II.

Of the intermission of action in animal life.

Consider, on the contrary, each organ of animal life in the exercise of its functions, you will observe in them constant and uniform alternations of activity and repose, complete intermissions and not remissions merely, as have been remarked in some organic phenomena.

Each sense when fatigued by long continued sensations, becomes for a moment unfit to receive them anew. The ear is not excited by sounds, the eye closes to the light, savours no longer irritate the tongue, odours find the *pituitary* insensible, and the touch becomes obtuse, simply because the respective functions of these organs have been long in exercise.

Fatigued by a continued exercise of perception, imagination, memory or meditation, it is requisite that the brain should recover, by an absence of action proportioned to the duration of activity which preceded it, those powers without which it could not again become active.

Every muscle which has been strongly contracted, requires a certain period of relaxation, before it can be again excited to contraction. Hence the necessary intermissions of locomotion and voice.

Such then is the peculiar character of each organ of animal life, that when fatigued, it is necessary it should cease to act for a time, in order to recover its exhausted strength.

The intermissions of animal life may be partial or general. It is partial when one organ has been long in exercise, while all the rest remained inactive. This organ is then relaxed; it sleeps while the others watch. This is no doubt

the reason, why each animal function is not in a state of immediate dependance upon the others, as we have observed to be the case in organic life. The action of the brain may exist, that is to say, the operations of memory, imagination, and reflection may be carried on in it, though the senses be closed to sensations. The same may happen with locomotion and voice; these being interrupted, the senses may receive external impressions notwithstanding.

The animal has it in his power separately to fatigue such or such a part. Each part therefore should have within itself the power of relaxation, and of thus recovering its strength: this is the partial sleep of the organs.

SECTION III.

Application of the law of intermission of action, to the theory of Sleep.

General sleep is the *totality* of individual or particular sleep; it is the result of that law of animal life which directs a constant connexion between the periods of activity and intermission in its functions, a law which, as we have seen, distinguishes it in a special manner from organic life; on this last, sleep has only an indirect influence, while over the former it exercises entire control.

Numerous varieties are observed in this periodical state to which all animals are subjected. The most complete sleep is that wherein the whole external life, the sensations, perception, imagination, memory, judgment, locomotion, and voice, are suspended; the least perfect, on the contrary, is that which affects only an individual organ; it is this of which we just now spoke.

Numerous intermediate degrees are observed between these two extremes: sometimes the sensations, perception, locomotion, and voice only are suspended, while imagination, memory, and judgment remain in exercise; sometimes to the exercise of these faculties is superadded that of locomotion and voice:* as in sleep disturbed by dreams, which are nothing more than a portion of animal life escaped from the torpor into which it had been thrown.

Sometimes three or four senses only cease their communication with external objects: as in that species of somnambulation in which, to the uninterrupted action of the brain, the muscles, and the larynx, are often very distinctly united the senses of hearing and of touch.

* The varieties in sleep are so numerous, and the ludicrous results so generally observed, that it may be perhaps considered superfluous, to add any farther instance of peculiarity: but as the following is known only to few; and the Translator, being intimately acquainted with the subject of it—able to vouch for its truth, he trusts the reader will excuse, at the same time that he may derive some amusement from this trifling claim on his attention. A respectable farmer, now considerably advanced in life, who has been a somnambulist from his infancy, and who in his nocturnal rambles has committed many an innocent robbery on his mother's larder to the no small diversion of his youthful associates, not many years ago, arose in the night, dressed himself completely, and to the inexpressible terror of his lady, seized the bed with her in it, carried it in his arms into an adjoining room, and carefully placed it on the hearth—after this wonderful exercise of his muscular strength, he walked out to a house at some distance occupied by one of his servants, roused him up, and in so distinct and particular a manner ordered him to set off immediately in the waggon, with certain produce of the farm to a neighbouring town, and there await his arrival, that the servant did not hesitate to obey. The gentleman then returned to his affrighted lady, quietly undressed himself, and passed the remainder of the night in bed. Upon awaking the next morning and discovering to his unfeigned astonishment that his eyes were directed up the chimney, he demanded of his wife how and why the bed had been placed in such a situation!—The irritability of his temper is so great on these occasions, that any attempt to impede or contradict his inclinations would be attended with the most dangerous consequences. T.

We cannot, therefore, look upon sleep as a state constant and invariable in its phenomena. Scarcely do we sleep twice in succession after the same manner: it is regulated by numerous causes, according to the subjection of a greater or less portion of animal life to the general law of intermission of action. Its different degrees must be marked by the different functions which this intermission affects.

The principle, however, is the same, from the simple relaxation which in a voluntary muscle succeeds to contraction, even to the total suspension of animal life. Throughout, sleep depends upon this general law of intermission, the exclusive character of this life; but its application to the different external functions vary without end.

There is without doubt a great difference between these ideas on sleep and those contracted systems where its cause, placed exclusively in the brain, the heart, the great vessels, stomach, &c., presents an insulate, and often illusory phenomenon, as the basis of one of the great modifications of life.

Why are light and darkness, in the order of nature, regularly coordinate to the activity and intermission of the external functions? It is because during the day a thousand means of excitation surround the animal, a thousand causes exhaust the powers of his sensitive and locomotive organs, bring on their lassitude and prepare a relaxation which the night favours by the absence of all stimuli. Hence in the manners of the present day, this order is partially inverted; we collect around us during the dark, different exciting causes to prolong the watch, and not until the first hours of light do we comply with the law of intermission, which it is necessary for us then to favour, by removing from the place of our repose every thing which can excite our sensations.

We may, for a certain time, withdraw the organs of animal life from the law of intermission, by multiplying around them the causes of excitement; but they must at last submit to it, and after a certain period nothing can suspend its influence. Exhausted by long watch, the soldier sleeps at the mouth of the cannon, the slave under the smart of the lash, and the criminal in the midst of the torments of the rack.

We must distinguish, however, natural sleep which is the consequence of a lassitude of the organs, from that which is the effect of an affection of the brain, of apoplexy, &c., for example. Here the senses watch, they receive impressions and are affected as usual; but these impressions not being perceived by the diseased brain, we can feel no consciousness of them. In the ordinary state, on the contrary, the intermission of action has as much or more influence on the senses than on the brain.

It follows from what has been said, that from the nature of organic life it endures much longer than animal life: indeed the sum of the periods of intermissions of the latter, to that of its time of activity is almost in the proportion of one half; so that our *internal* life exists double the time of our *external* life.

ARTICLE V.

GENERAL DIFFERENCES OF THE TWO LIVES WITH RESPECT TO HABIT.

ANOTHER of the grand characters which distinguish the two lives of the animal, is the independence on habit enjoyed by the one, compared to the influence which it has on the other.

SECTION I.

Of habit in animal life.

EVERY thing is regulated by habit in animal life; each function, enervated or brought to perfection by it, appears to assume different characters, according to the different periods in which it is exercised: in order correctly to estimate its influence, it will be necessary to note two things in the effect of sensations, namely, *feeling* and judgment. A song strikes our ear; its first impression, without our knowing why, is painful or agreeable; this constitutes the feeling. If the song is continued, we endeavour to estimate the different sounds of which it is made up, and distinguish their accords; this constitutes the judgment. Habit acts in an inverse ratio upon these two things. The feeling is constantly blunted by it, whereas the judgment on the contrary owes to it its perfection. The more we look at an object, the less are we sensible of its painful or agreeable qualities and the better do we judge of all its attributes.

SECTION II.

Habit blunts the feeling.

In the first place I observe that the property of habit is to obtund the feeling, to reduce pleasure or pain constantly to a state of indifference which is the medium between them. But before we attempt to prove this remarkable assertion, it may be proper to render the meaning of it clear and intelligible. Pain and pleasure are either absolute or relative. The instrument which tears our skin and the consequent inflammation, cause an absolute pain; coition is a pleasure of the same nature. The view of a beautiful country delights us; but here the enjoyment is relative to the actual state of the mind: for to the inhabitant of this country, its sight has become indifferent. When a probe is introduced for the first time into the urethra; it is painful to the patient; but in a few days he becomes no longer sensible of it; this is a comparative pain. Every thing which acts upon our organs by destroying their contexture, is always the cause of an absolute sensation; the simple contact of a body with our own, produces only a relative sensation.

It is hence evident, that the empire of absolute pleasure or pain, is much more contracted than that of relative pain or pleasure; that the words *agreeable* and *painful*, almost always suppose a comparison between the impression which the senses receive, and the state of the mind which perceives the impression. It is clear, therefore, that relative pleasure and pain only can be subject to the dominion of habit; and of these only we shall speak.

There are proofs on proofs to establish the position that every species of relative pleasure or pain, is incessantly brought to a state of indifference by the influence of habit. Every foreign body coming in contact for the first time with a mucous membrane, produces a disagreeable and even painful sensation in it, which is daily diminished until it becomes perfectly insensible. Pessaries in the vagina, suppositories in the rectum, the instrument used in cases of polypus in the nose or matrix, probes in the urethra, in the œsophagus, or the trachea arteria, stilettoes, and setons in the lachrymal passages, invariably present this phenomenon. Those impressions, the seat of which is in the skin, are all subject to the same law. The sudden transition from cold to heat or from heat to cold always produces a disagreeable sensation, which is gradually done away, if the atmosphere remains at the same degree of temperature. Hence the various sensations caused in us by the changes of season, climate, &c. Similar phenomena result from the successive perception of the humid or dry, soft or hard qualities of bodies in contact with our own. In short, every sensation which differs widely from that which precedes it, produces a *feeling* which is soon worn off by habit.

We may say the same of pleasure that we have said of pain. The perfumer surrounded by an odoriferous atmosphere, and the cook whose palate is incessantly affected by the most delicious savours, do not experience in the exercise of their professions, those lively enjoyments which they prepare for others, because in them the habit of feeling blunts the sensation. The effect is the same where the agreeable impressions are seated in the other senses. Whatever attracts the eye, or agreeably strikes the ear, only afford us pleasures whose vivacity is soon diminished. The most beauteous spectacle, or the most harmonious sounds are successively the source of pleasure, indifference, satiety, disgust, and even aversion, by their continuance only.

This remark has been made by every body, though poets and philosophers each after their manner have taken it to themselves.

Whence arises that facility with which our sensations can undergo so many different and often opposite modifications? In order to conceive it, it may be necessary to remark that the *centre* of those revolutions of pleasure, of pain, and of indifference is not in the organs which receive or transmit the sensation, but in the mind which perceives it: the affection of the eye, of the tongue, or of the ear, is always the same: but we attach to this affection varieties of feeling.

We must remark in the next place that the action of the mind on each feeling of pain or of pleasure, arising from a sensation, consists in a comparison between that sensation and those which have preceded it, a comparison which is not the result of reflection, but the involuntary effect of the first impression of objects. The greater the difference between the actual and past impressions, the more ardent will be the feeling. That sensation would affect us most which we had never experienced before.

It follows therefore that our sensations make a greater or less impression upon us according to the frequency of their repetition, because the comparison becomes less sensible between their passed and actual state. Every time that we see an object, hear a sound, or taste a dish, &c. we find less difference between what we experience, and what we have experienced.

The nature of pleasure and of pain is to destroy themselves, to cease to exist, because they have existed. The art of prolonging the duration of our enjoyments consists in varying their causes.

I could almost say, if I had regard only to the laws of our *material* organization, that *constancy* is the happy dream of poets, that happiness is to be found only in *inconstancy*,

that the attractions of the *fair sex* would have but feeble hold on our homage, if they were too uniform, that if the figure of every woman was cast in the same mould this mould would be the tomb of love, &c. But we should be cautious how we employ *physical* principles to overturn those of morality: both are equally solid, though occasionally in opposition. We may remark that the first often govern us entirely; then love like other sensations under the influence of habit, flies off with pleasure and leaves us only disgust; then remembrance steps in with a ready period to constancy, by rendering uniform what we *feel* and what we have *felt:* for such appears to be the essence of physical happiness, that what is past dulls the attraction of what we actually enjoy. Behold that man now devoured by ENNUI, in presence of her, in whose company his hours once passed with the rapidity of lightning; he would *be* happy if he had *not been* so, or if he could forget that he had ever been. Remembrance then may be said to be the only happiness of unfortunate lovers: but we must avow also, that it is the only evil of the happy.

We must acknowledge that physical pleasure, is only a comparative *sentiment*, that it ceases to exist the moment a uniformity is created between our actual sensations and past impressions, and that it is by producing this uniformity that habit is incessantly leading us to indifference: this is the whole secret of the immense influence it exercises over our enjoyments.

Such also is its mode of action on our pains. It is said, time flies when it removes our troubles; it is the surest remedy. And why? because the more it accumulates our sensations of what has been painful, the more it weakens the *sentiment* of comparison established between what we are and what we were. There is in short an epoch in which sentiment is extinguished; so it is by continual grief: every thing must yield to the irresistible ascendency of habit.

SECTION III.

Habit perfects the judgment.

I HAVE endeavoured to prove that whatever is allied to *sentiment* in our relations with what surrounds us, is enfeebled, enervated, and rendered null by the effect of habit. It is easy to demonstrate on the contrary that it advances and perfects whatever is connected to the judgment formed according to those relations.

When for the first time the eye is extended over a vast country, the ear assailed by music, the taste or smell affected by a complicated savour or odour, confused and imperfect ideas are formed from these sensations; we jumble them together; and the particulars escape us. But let these sensations be repeated, and habit render them familiar, then our judgment becomes precise and correct; it embraces all; the knowledge of the object which has attracted us, irregular as it was, becomes perfect.

So with the man who, for the first time, visits the opera; a stranger to every kind of spectacle, his ideas of them are vague. The dancing, musick, decorations, play of the actors, and brilliancy of the assembly are all confounded in a delightful chaos. But after he has been present at several representations, his mind begins to appropriate to their proper head the different acts which compose this charming spectacle, he soon becomes familiar to the particulars; then he is able to judge, and this he does with a correctness in proportion to the frequency of opportunities afforded him of seeing it.

This example offers us an epitome of man beginning to enjoy the spectacle of nature. The infant just born, and

to whom every thing is new, can perceive in what strikes his senses, only general impressions. As these impressions which at first occupy all his attention are gradually lessened by habit, he is enabled to catch the different attributes of bodies; and thus by insensible degrees to see, hear, feel, taste, and touch; precise ideas of particular objects having succeeded to his confused notion of the whole.

Habit then as it obtunds the feeling, constantly perfects the judgment, and this second effect is inevitably connected to the first. An example will render this evident: I walk through a meadow enamelled with flowers; a general odour, a confused mixture of all those which these flowers would separately furnish, attracts me at first; distracted by it, the mind can perceive nothing else; but habit weakens this first sentiment; in a short time it is entirely effaced; then the particular odour of each plant is distinguished, and I am enabled to form a judgment which was at first impossible.

These two opposite modes in which habit exercises its influence over the feeling and judgment, tend, as has been seen, to one common end, and this end is the perfection of every act of animal life.

SECTION IV.

Of habit in organic life.

CONTRARY to the phenomena of animal life, we shall see that those of organic life are constantly withdrawn from the empire of habit. Circulation, respiration, exhalation, absorption, nutrition, the secretions, are not regulated by it. A thousand accidents would daily threaten our existence, if these essential functions were subject to its influence.

The excretions of urine and fæces, however, may sometimes be suspended or accelerated according to the rules of habit; the action of the stomach in hunger, in the contact of different kinds of food, appears also to be subordinate to it; but we must remark that these different phenomena holding the middle rank between those of the two lives, are found at the limits of both, and thus partake as much of the one as of the other. All in fact pass over the mucous membranes, a sort of organs which, always in connexion with bodies foreign to our own substance, are the seat of an internal touch, analogous in every thing to the external touch of the skin or the bodies which surround us. This touch or feeling must therefore be subject to the same regulations: should we be astonished then at the influence which habit exercises over it?

We may remark, besides, that the greater part of these phenomena, relative to the first or last sojourn of the food in the parts it is destined to nourish, phenomena which begin, to speak thus, and terminate organic life, draw after them different motions *essentially* voluntary, and consequently belonging to animal life.

I shall not here take into view a number of other modifications in the strength, tastes, desires, &c. which have their source in habit. I refer to the numerous works in which its influence has been considered in different points of view from that which I have presented.

ARTICLE VI.

GENERAL DIFFERENCE OF THE TWO LIVES MORALLY CONSIDERED.

WE must consider under two heads those acts which, but little connected with the material organization of animals, result from that principle so little known in its nature, but so remarkable in its effects, the mainspring of all their voluntary motions, and about which authors would have disputed less, if, without endeavouring to trace it to its essence, they had been contented to analyze its operations. These acts, which we consider particularly in man where they are at their highest point of perfection, are either purely intellectual, and relative only to the understanding, or the immediate production of the passions. Examined in the first point of view, they are the exclusive attribute of animal life: considered in the second, they belong essentially to organic life.

SECTION I.

Whatever relates to the understanding belongs to animal life.

IT is useless, I trust, to occupy much time in endeavouring to show that meditation, reflection, judgment, every thing, in short, depending on an association of ideas, are the province of animal life. We form our judgment from

the impressions received heretofore, those which we actually receive, or from those which we ourselves create.

Memory, perception, and imagination, are the principal bases upon which rest all the operations of the understanding; these foundations themselves rest upon the action of the senses.

Suppose a man born deprived of all that outward apparel which establishes our relations with surrounding objects; such a man would not be altogether the statue of CONDILLAC; for, as we shall see, other causes than the sensations may determine us to the exercise of the motions of animal life; but no less a stranger to all that surrounded him, he would be unable to judge, because the materials of judgment would be wanting in him; every species of intellectual function would be null in him; the will, which is the result of these functions, could not have place; consequently that widely extended class of motions which has its immediate seat in the brain, and which is a consequence of the impressions it has received from external objects, would be entirely lost to him.

It is, therefore, by animal life that man is so great, so superior to the beings around him; by it he appertains to the sciences, to the arts, to every thing which raises him above the gross attributes by which he represents matter and allies him to the sublime images he forms of spirituality. Industry, commerce, every thing which is delightful, every thing which enlarges the narrow circle of animal existence, is the appurtenance of the external life.

Actual society is nothing else but a more regular development, a more marked perfection in the exercise of the different functions of this life, which establish our relations with surrounding beings; for, as I shall particularly prove, it is one of its important characters, to be susceptible of extension and perfection, while in organic life every part

is unchangeably fixed to the limits Nature has assigned it. We live organically in a manner altogether as perfect and as regular in infancy as in adult age; but compare the animal life of a child to that of a man of thirty, and the difference will be easily seen.

After what has been said, the brain, the central organ of animal life, may be considered also as the centre of every thing which has relation to intelligence or to the understanding. I might here speak of its proportion of size in man and other animals, where the ingenuity appears to decrease as the *facial angle* becomes more acute and the cerebral cavity more contracted, of the different aberrations of which it is the seat, and which are all marked by perceptible alterations in the understanding. But these are all sufficiently known. We pass now to the other order of phenomena, which, foreign like the preceding, to the ideas which we form of material phenomena, have notwithstanding a seat essentially different.

SECTION II.

Whatever relates to the passions belongs to organic life.

My object is not here to consider the passions in a metaphysical view. Whether they are all only different modifications of a single passion; or whether each depends on a separate principle, is of no consequence: let us remark only that many physicians in treating of their influence on organic phenomena have not sufficiently distinguished them from sensations. The latter occasion the former, but they are essentially different.

Anger, sadness, and joy, would not, it is true, agitate our minds, if we did not find in our relations with external objects the causes which created them. It is also true that the senses are the agents of these relations, that they communicate the cause of the passions, but they do not in any manner participate the effect; simple conductors, in this case, they have nothing in common with the affections they produce. So true is it, that every kind of sensation has its centre in the brain, for every sensation supposes an impression and perception. The senses receive the impression, and the brain perceives it; so that when the action of this organ is suspended all sensation ceases. On the contrary it is never affected by the passions; the organs of internal life are their only seat.

It is certainly astonishing that the passions which enter essentially into our relations with the beings around us, which regulate these relations at every moment, without which animal life would be only a dull series of intellectual phenomena, and which animate and exalt all the phenomena of this life; it is, I say, astonishing that the passions have neither their end nor their origin in the different organs of this life, but that the parts subservient to the internal functions are constantly affected by them, and are ever determined according to the state in which they may be. Such, however, is what strict observation will prove to us.

I have said, that the effect of every kind of passion, constantly foreign to animal life, is to produce some change, some alteration in organic life. Anger accelerates the circulation, and increases, often in an incommensurable proportion, the effort of the heart: it is on the force, the rapidity of the course of the blood that it maintains its influence. Joy affects the circulation also, but without producing so sensible a change; it develops its phenomena in

greater plenitude, accelerates it gently, and determines it towards the surface. Fear acts in an inverse ratio; it is characterised by a feebleness in the whole vascular system, a feebleness which, preventing the arrival of the blood to the capillaries, produces that general paleness, which is observed in the body, and particularly in the face. The effect of sadness and trouble is somewhat similar.

Such indeed is the influence which the passions exercise over the circulatory organs, that they sometimes, when the affections are very violent, operate so far as to stop the play of those organs; hence syncope, the primitive seat of which, as I shall soon prove, is always in the heart, and not in the brain, which ceases to act only because it no longer receives the necessary stimulus to action. Hence even death, which is sometimes the sudden effect of extreme emotions; whether these emotions so far increase the circulatory powers, that, suddenly exhausted, they are unable to recover, as in death produced by a fit of anger; or whether, as in that occasioned by violent grief, the powers all at once struck with excessive debility, cannot recover their ordinary state.

If a total or instantaneous cessation of the circulation is not brought on by this debility, the parts often retain a lasting impression of it, and become afterwards the seat of various organic injuries. Dessault remarked that diseases of the heart and aneurisms of the aorta were multiplied during the revolution in proportion to the evils which it brought forth.

Respiration has a no less immediate dependence on the passions: those suffocations, that oppression, the sudden effect of profound grief, do they not indicate some remarkable change, some sudden alteration in the lungs? In the long catalogue of chronic diseases, or of acute affections, the sad attribute of the pulmonary system, are we not often

obliged to trace the different passions of the patient to discover the principle of his disease?

The lively impression felt at the *pylorus* in strong emotions, the indelible mark which it sometimes retains of it, and which produces those schirri seated in it, the sense of oppression which is experienced in the whole region of the stomach, in the *cardia* particularly; under other circumstances, the spasmodic vomitings which sometimes suddenly succeed to the loss of a beloved object, to the news of an unhappy accident, the sudden interruption to the digestive phenomena by agreeable or sorrowful news, the affections of the bowels, the organic injuries of the intestines, and of the spleen observed in *melancholia* and *hypochondriasis*—do not all these indicate the direct connexion between the passions and the viscera belonging to digestion?

The secretory organs have a no less remarkable connexion with the affections of the mind. A sudden fright suspends the course of the bile, and brings on jaundice; a paroxysm of anger is frequently the cause of a predisposition and even of bilious fever; the tears run copiously in grief, in joy, and sometimes in admiration; the pancreas is frequently diseased in *hypochondria*, &c.

Exhalation, absorption, and nutrition do not appear to receive from the passions so direct an influence as the circulation, digestion, respiration, and the secretions; but this no doubt is because these functions have not like the latter any principal *focus*, any essential viscera whose situation we may compare with that of the mind. Their phenomena dispersed generally throughout all the organs, and belonging exclusively to none, cannot strike us so forcibly as those, the effect of which is concentrated in a narrower space.

The alterations which they experience, however, are not less real, and after a certain time become no less apparent. Compare the man, whose days are marked by grief, to one whose time is passed in peace of heart and tranquillity of mind, and you will see what difference distinguishes the nutrition of the one from the other.

Call to remembrance the time when every doleful passion, fear, sadness, desire of revenge, &c. appeared to hover over France, and compare it with that when safety and abundance called forth the gayer passions, so natural to the French; it will be found upon recollecting the external habit of the different bodies, that nutrition received some influence from the passions. The expressions, *to pine with desire*, *to be tormented with remorse*, *to be consumed by sadness*, *&c.* do they not announce this influence, do they not indicate how much the passions regulate the nutritive process?

Why should not absorption and exhalation be also subject to their empire, though they appear less to be? May not those watery collections, dropsies, &c. the particular vices of these two functions, often depend on our moral affections?

In midst of these disorders, of these partial or general revolutions produced by the passions in the organic phenomena, consider the actions of animal life; they remain constantly the same, or if they experience any discomposure, the primitive source, as I shall show, is always in the external functions.

We may conclude then from these various considerations, that it is always over organic and not over animal life, that the passions bear sway: thus whatever serves us to display them, relates to the first and not to the second. Gesture, a dumb expression of the *sentiment* and not of the understanding, is a remarkable proof of this: if we in-

dicate any intellectual phenomena relative to memory, imagination, perception, or judgment, the hand is involuntarily carried to the head: when we wish to express love, joy, sadness, or hatred, it is directed to the heart, stomach, or intestines.

An actor who should commit an error in this respect, and who in attempting to paint distress, should carry his gestures to the head, or should confine them to the heart to announce an effort of genius would cover himself with ridicule.

The respective attributes of the two lives were distinguished by common language, at the time when the literati referred all our affections to the brain, as the seat of the mind. *A strong head*, or *a well organized head*, has always been the phrase to express the perfection of the understanding; *a good heart*, *a feeling heart*, to show that of the *sentiment*. The expressions, *fury circulating in the veins*, *stirring up the bile*, *the bowels leaping for joy*, *jealousy distilling its poisons in the heart*, *&c. &c.* are not poetical metaphors, but the expression of what is really in Nature. Thus all those expressions borrowed from the internal functions, are found particularly in our songs which are the language of the passions, and consequently of organic life, as our common speech is that of the understanding, and of animal life. Declamation holds the middle rank; it animates the dull language of the brain, by the expressive language of the internal organs of the heart, liver, stomach, &c.

Anger, that *inoculating* affection (to use the expression) to the humours and the saliva in particular, that radical quality which renders the bite of animals, agitated with it, dangerous, does truly, as the common expression serves to show, distil a fatal poison in the fluids. The violent passions of the nurse often impress a destructive character

on the milk which is the cause of numerous maladies in the child. It is from the modifications which the blood of the mother undergoes from the different emotions she experiences, that we must explain how these emotions can influence the nutrition, conformation and even life itself of the fœtus, to which the blood is carried through the medium of the placenta.

Not only do the passions in a particular manner govern the organic functions by affecting their viscera, but the state of these viscera, their injuries, variations of force, &c. concur in an especial manner to the production of the passions. Their close connexion with the temperament, age, &c. incontestably establishes this fact.

Who does not know that the individual whose pulmonary system is strong, whose circulatory system enjoys much energy, and who is, as it is termed very sanguine, possesses an impetuosity in his affections which disposes him particularly to anger, transport, courage, &c.; that where the bilious system predominates, certain passions, such as envy, hatred, &c. are more strongly evinced; and that those constitutions in which the functions of the lymphatic system have an ascendancy impress on the affections a dullness very opposite to the impetuosity of the sanguine temperament.

In general, what characterizes this or that temperament, is a modification in the passions on the one hand, and of the state of the visera of organic life and the predominance of one or the other of its functions, on the other hand. Animal life is almost constantly a stranger to the peculiarities of the temperaments.

We may say the same of the different ages. In infancy, the weakness of organization coincides with timidity and fear; in youth courage and boldness display themselves in proportion as the pulmonary and vascular systems are

superior to the rest; manhood, in which the liver and gastric system are well developed, is the age of ambition, envy, intrigue, &c.

If we consider the effect of climate, season, &c. on the passions, the same connexion will be observed between them and the organs of the internal functions; but enough has been said by physicians of those analogies; it would be superfluous to repeat them.

If from man in a state of health we extend our observations to his state of disease, we shall see that injuries in the liver, stomach, spleen, intestines, heart, &c. produce a variety of alterations in the affections, which cease to have place the moment the cause is removed.

Those ancients who believed that gloomy and melancholy affections could be carried off by purgatives along with the bad humours, knew better than our modern mechanicians the laws of the human economy. By cleansing the *primæ viæ* they removed the cause of these affections. With what a melancholy hue are we overspread by any obstruction in the gastric organs.

The errors of the first physicians with respect to *atrabilis*, proved the correctness of their observations on the relations existing between these organs and the state of the mind.

Every thing then tends to prove that organic life is the goal at which the passions terminate, and the source from which they take their rise. It will perhaps be asked here, why vegetables which live organically present no vestige of them? It is because, besides their wanting the natural exciting cause, that is, the external sensitive system, they are deprived of those internal organs which more especially concur to their production, such as the digestive system, that of the general circulation, of the secretions, &c. which are possessed by animals; they respire by means of *tracheæ*, and not by a concentrated focus, &c.

Hence it is that the passions are so obscure, and even sometimes wanting in the genus of zoophytes, worms, &c. and hence also it is that in a series of animals, in proportion as organic life is more simplified, or loses its important organs, the passions decrease.

SECTION III.

The passions regulate the actions of animal life though they have their seat in organic life.

Though the passions are the particular attribute of organic life, they have however, an influence on the motions of animal life which it is necessary to inquire into. The voluntary muscles are frequently put in play by them; sometimes they have a stimulating action, and sometimes they appear to act in a sedative manner.

Observe the man agitated by anger and fury; you will find his muscular powers are doubled, are exercised with an energy which he himself cannot moderate; where shall we look for the source of this increase? It is manifestly in the heart.

This organ is the natural *exciter* of the brain by means of the blood which it sends to it, as I shall prove in the course of this work, so that according as the excitement is more or less powerful, the cerebral energy will be greater or less, and we have seen that the effect of anger is to give an extreme vivacity to the circulation, and consequently to send towards the brain a large quantity of blood in a given time. A similar effect results in the paroxysms of ardent fevers, in the use of wine to a certain degree, &c.

The brain when strongly excited, communicates force to the muscles which are subject to its influence; their motions become, to use the expression, involuntary: thus is the will a stranger to those muscular spasms produced by a cause which irritates the medullary organ, as the splinter of a bone, blood, pus in wounds of the head, or the handle of any instrument in our use.

The analogy is exact; the blood arriving at the brain in larger quantities than usual, produces upon it the effect of those different exciters just mentioned. It is, however, passive in these different motions. It is, to be sure, from it that the necessary irradiations proceed as usual, but these irradiations are produced there in spite of it, and we have not the power to suspend them.

Observe further, that in anger, a constant connexion exists between the contractions of the heart and those of the locomotive organs: where the former are augmented, the latter increase also; if an equilibrium is established on the one side, we soon observe it on the other. In no other case, on the contrary, does any appearance of this connexion manifest itself; the action of the heart remains the same notwithstanding numerous variations in the locomotive muscular system. In convulsions or paralysis, of which this system is the seat, the circulation is never either retarded or accelerated.

In anger we see the kind of influence which organic life exercises over animal life. In fear where, on the one hand, the enfeebled powers of the heart push on to the brain less blood, and consequently direct thither a slighter cause of excitement; and where on the other hand a feebleness of action is remarked in the external muscles, we observe plainly the connexion between the cause and effect. This passion offers in the first degree, the phenomenon which is presented in the last, by those powerful emotions,

which suspending all at once the effort of the heart, produce a sudden cessation of animal life, and consequently syncope.

But how shall we apply the thousand varied modifications which the other passions at every instant, give to the motions which belong to this life? How explain the cause of those infinite shades which succeed each other so often with an inconceivable rapidity in the changeable picture of the face? or why independent of the will, the forehead frowns or expresses cheerfulness, the eyes look fierce or languishing, bright or obscure, &c.

All the muscles which are the agents of these motions receive their nerves from the brain, and are ordinarily voluntary. Why do they cease to be so in the passions? Why do they enter into that class of motions of organic life, which are exercised without our direction, or without even our consciousness? The following is, I think, the most probable explanation of this phenomenon.

Numerous sympathetic relations unite all the internal viscera with the brain or its different parts. Every day's practice affords us examples of affections of this organ, arising sympathetically from those of the stomach, liver, intestines, spleen, &c. This being premised, as the effect of every kind of passion is to produce an affection, a change of force in some one of these viscera, it will also excite sympathetically either the brain wholly, or only some of its parts whose reaction on the muscles which receive it from the nerves, will produce in them those motions which are observed. In the production of these motions, the cerebral organ is, if we may say so, passive, while it is active when the will presides over its efforts.

What happens in the passions is similar to what we observe in diseases of the internal organs, which produce

sympathetically spasms, weakness or even paralysis of the locomotive muscles.

Perhaps the internal organs do not act upon the voluntary muscles by the intermediate excitement of the brain, but by direct nervous communications; how they act is of no consequence. The question here is not as to their mode of action, but as to the existence of these sympathetic communications.

What is most essential, is the fact itself; what is evidently in support of it is: on the one part, the affection of an internal organ by the passions; on the other part, the determinate motion to this affection in muscles over which this organ has no influence, in the ordinary series of the phenomena of the two lives. This is certainly sympathy; for between it and what is presented to us by convulsions and spasms of the face, occasioned by an injury in the *phrenic* centre, by a wound in the stomach, &c. the only difference is in the cause which affects the internal organ.

The irritation of the palate, or of the pharynx agitates the diaphragm convulsively; the frequent action of fermented liquors on the stomach produces tremors: why should not the same which happens in one mode of affection of the gastric viscera, take place in another? Whether the stomach, liver, &c. be irritated by a passion, or by a material cause, of what consequence is it? It is from the affection, and not from the cause which produces it, that sympathy arises.

This then, generally is the way in which the passions snatch from the empire of the will, motions which are naturally voluntary, and in which they appropriate to themselves, if I may thus express myself, the phenomena of animal life, though they hold their seat essentially in organic life.

When they are violent, the powerful affection of the internal organs produces such impetuosity in the sympathetic motions of the muscles that the ordinary action of the brain is absolutely null. But the first impression being past, the usual mode of locomotion returns.

A man learns by letter, and before a company, news which he is interested in concealing; all at once his brow contracts, he grows pale, or his features are animated, according to the passion which has been excited: here are sympathetic phenomena arising from some of the abdominal viscera suddenly affected by this passion, and which consequently, belong to organic life. This man very soon constrains himself; his brow is smoothed; his colour returns, or his features are contracted, though the sentiment still exists internally: this is because the voluntary motions have regained their superiority over the sympathetic; because the action of the brain has surmounted that of the stomach, liver, &c.: in short, because animal life has recovered its empire.

There is in almost all the passions, a mixture or a succession of the motions of animal to those of organic life; so that, in almost all, the muscular action is directed partly by the brain in the natural order, and partly has its seat in the organic viscera, the heart, liver, stomach, &c. These two foci (foyers) alternately predominating over each other, or remaining in equilibrium, constitute by their mode of influence, all the numerous varieties which our moral affections present to us.

It is not only on the brain, but on every other part, that the viscera affected by the passions exercise their sympathetic influence: fear affects the stomach primitively, as the contraction experienced in this region proves. Thus affected, this organ reacts upon the skin with which it has so much connexion, and the latter then becomes the seat

of a cold and sudden sweat, so frequent in this affection of the mind. This sweat is of the same nature with those produced by any substance which, like tea, acts first upon the stomach, which last reacts sympathetically upon the cutaneous organ. Thus a glass of cold water, or a stream of air will suppress this excretion, by means of the connexion which exists between this organ and the mucous surfaces of the stomach or the bronchiæ. These sympathetic sweats, however, must be distinguished from those produced by a cause acting directly on the skin, such as heat, air, &c.

Though the brain, after what has been said, may not be considered the only mark of the reaction of the internal viscera affected by the passions, it is notwithstanding the principal one, and under this respect may always be considered as a focus constantly in opposition to that presented to us by the internal organs.

SECTION IV.

Of the epigastric centre; it does not exist in the sense in which authors have understood it.

Authors have never differed about the cerebral focus; all the voluntary motions have been considered by them as an effect of its irradiations. But they are not agreed in their opinion of the epigastric focus; some place it in the diaphragm, others in the pylorus, and some others in the solar plexus of the great sympathetic.*

* This nervous entanglement, produced principally from the semilunar ganglion, belongs to almost the whole abdominal vascular system, whose different ramifications it closely follows. It is, as it is usually seen, one

All appear to me to err on this point, in this, that in assimilating the second, to the first focus, they believe that the passions like the sensations have one uniform and invariable centre.

of the divisions of the great sympathetic; but it appears to me that the ideas of anatomists upon this important nerve, are very little conformable to what nature presents to us.

It is represented by every body as a medullary cord, extending from the head to the sacral region, sending off in its course, different ramifications to the neck, breast and lower belly, following in its distributions a course analogous to that of the nerves of the spine, and having its origin from these nerves as well as from the brain. Whatever may be the name by which it is designated, sympathetic, intercostal, &c., the manner of regarding it is always the same.

I believe that this method of considering it is entirely false, that there exists really no such nerve as that designated by these words, and that what is taken for a nerve is nothing more than a course of communications between different nervous centres placed at different distances from each other.

These nervous centres are the *ganglions*. Disseminated throughout the different regions, they have all an independent and separate action. Each one is a particular *focus*, which sends out in different directions numerous ramifications which carry in their respective organs, the irradiations of the focus from which they escape. Among these ramifications, some go from one ganglion to another; and as these branches which unite the ganglions, form altogether a sort of continued *cord*, this cord has been considered as a separate nerve; but these branches are only communications, simple *anastomoses*, and not a nerve like the others.

This is so true, that these communications are often interrupted. There are subjects, for example, in whom a very distinct interval is found between the pectoral and lumbar portions of what is called the great sympathetic, which appears in that place to be cut. I have likewise seen this pretended nerve vanish and reappear, in the lumbar as well as in the sacral region. Who does not know that sometimes a single branch, and sometimes several pass from one ganglion to another, particularly between the last cervical and the first dorsal vertebræ, that the volume of these branches vary in a singular manner, and that after having furnished numerous divisions, the *sympathetic* is larger than before it distributed any

What has induced this opinion, is that sensation of oppression which is felt in the neighbourhood of the *cardia* in painful affections.

But we must remark that in the internal organ, the sensation arising from the affection of a part, is always a de-

These different considerations evidently prove that the communicating branches of the ganglions no more suppose one continued nerve, than the branches which pass from each of the cervical, lumbar or sacral pairs, to the two pairs which are inferior and superior to it. Indeed, notwithstanding these communications, each pair is considered in a separate manner; it is not pretended that their assemblage constitutes a nerve.

Each ganglion should also be regarded separately, and the branches which come out of them described.

Hence, I shall in future in my descriptions (in which I have hitherto followed the common method) divide the nerves into two great systems, the one emanating from the brain, the other from the ganglions: the first has one centre only; the second, a great number of them.

I shall first examine the divisions of the cerebral system; I shall then treat of the system of the ganglions, which may be subdivided into those of the head, neck, thorax, abdomen, and belly.

In the head are found the lenticular, that of Mekel, that of the sublingual gland, &c. Though no communication connects these different centres, either among themselves or with the pretended great sympathetic, their description, notwithstanding, belongs to that of the nerves of which this is made up, seeing that the communications are only dispositions accessary to the system of nerves.

In the neck the three cervical ganglions, sometimes another on the side of the *trachea arteria*, in the breast the twelve thoracics, in the abdomen the semilunar, the lumbars, &c. and in the belly the sacral; these are the different centres whose ramifications must be examined separately, as that of the cerebral centre is considered.

For example, I will in the first place describe the semilunar ganglion, as is done for the brain; I shall in the next place examine its branches, among which is placed that by which it communicates with the thoracic ganglions, that is to say, the great splanchnic; for it is very improper to say that this nerve gives birth to the ganglion. In the neck and head also each ganglion will be first described; then I shall treat of their branches among which are those of communication. The disposition being nearly common for the ganglions of the chest, belly, and loins, &c. the description will be pretty general for each region

ceitful indication of the seat and extent of that affection: for example, hunger extends its influence over the whole of the stomach, though the cardia alone appears to transmit the sensation to us. A large inflamed surface in the

This method of considering the nerves by placing a line of demarcation between their two great systems, presents these systems as they are really found in nature.

What anatomist has not been struck with the differences found between the nerves of the two systems? Those from the brain are larger, less numerous, whiter, more compact in their texture, and exposed to less frequent variations. On the contrary, extreme tenuity, very considerable numbers, particularly towards the plexus, a grayish colour, a remarkable softness of texture, and very common variations, are the characters of the nerves coming from the ganglions, if you except those of communication with the cerebral nerves, and some of those which unite among them those little nervous centres.

Besides, this division of the general system of the nerves accords with the division of life. It is well known that the external functions, the sensations, locomotion and voice are under the direction of the cerebral nervous system; that on the contrary most of the organs serving the internal functions take their nerves from the ganglions, and with them the principle of their action. It is known also that the animal sensibility and contractibility arise from the first; that from the second arise only organic sensibility and contractibility.

I have said elsewhere that the term of this kind of sensibility and the origin of the corresponding contractibility, are in the organ itself in which they are observed; but perhaps this term and origin are more distant, and exist in the ganglion from which the organ receives its nerves; as the end and origin of animal sensibility and contractibility, are always found in the brain. If this is the case, it may be easily conceived, as the ganglions are very numerous, why the powers of organic life do not refer, like those of animal life, to one common centre.

It is manifest, after these considerations, that there exists no such nerve as the great sympathetic, and that what is designated by this word, is no more than an assemblage of small nervous systems, having separate functions, but communicating branches.

What is to be thought then, of those disputes of anatomists about the origin of this pretended nerve, which has been fixed in the sixth, the fifth pair, &c. in those of the neck, the back? &c....

pleura, or in the lungs, most frequently produces a pain concentred in a small point. How often do we not observe that a fixed and circumscribed pain in the head, abdomen, &c. coincides with an affection widely extended, and even having its seat in a place entirely different from what we presume! We should never therefore consider the spot to which we refer the sensation, as the sure indication of the precise place that the affection occupies, but as a sign only that it is to be found there, or in the neighbourhood.

It follows from what has been said, that in order to form an idea of the organ with which this or that passion is in connexion, it is necessary to recur not only to the sensation, but to the effect produced in the functions of the organ, by the influence of the passion. Now, in departing from this principle, it is easy to see that it is sometimes the digestive organs, sometimes the circulatory system, and sometimes the viscera belonging to the secretions, which experience a change, a disturbance in our moral affections.

I shall not recur to the proofs which establish this truth, but resting upon it, as being demonstrated, I will say that there is no fixed and constant centre for the passions as there is for the sensations; that the liver, lungs, spleen, stomach, heart, &c. alternately affected, form by turns the epigastric focus, so celebrated in our modern works; that if we refer, in general, to this region, the sensible impres-

Several physiologists have entertained ideas of the ganglions similar to those I have just presented, considering these bodies as little brains; but it is necessary to correct these views in the description which, such as they present it, gives a very improper idea, both of the nervous centres, and of the nerves which go out of them.

The expression *nervous branches giving birth to such a ganglion, &c.* is as incorrect as to say that the brain is formed of the nerves, of which it is itself the origin

pression of all our affections, it is that all the important viscera of organic life, are found concentered there; that if nature had separated these viscera by great intervals, in placing for example, the liver in the belly, the stomach in the neck, while the heart and spleen remained in their proper places, then the epigastric focus would disappear, and the local sensation of our passions would vary according to the organ upon which they exercised their influence.

Camper, in determining the *facial angle*, has given place to some luminous considerations upon the respective intelligence of animals. It appears that not only the functions of the brain, but all those, in general, of animal life, which find in it their common centre, have pretty nearly this angle as the measure of perfection.

It would be very curious to point out also a measure, which, taken in the parts subservient to organic life, could fix the rank of each species under the head of the passions. Why is *sentiment* carried to so high a point in the dog? Why do recognition, sadness, joy, hatred, friendship, &c. agitate them so easily? In this respect he is superior to other animals: has he any thing more perfect in his organic life? The ape astonishes us by his ingenuity, his disposition to imitate, and by his intelligence; is it by the superiority of his animal life, that he leaves far behind him the best organized species? Other animals, as the elephant, interest us by their attachments, their affections, and their passions, and charm us by their address, the extent of their perception, and their intelligence. The cerebral centre, and the internal or organic functions, are in the same degree of perfection in them; nature appears to have equally enlarged the boundaries of their two lives.

A rapid glance at the series of animals, will thus show us, sometimes the phenomena relative to the sensations,

predominating over those arising from the passions, sometimes the latter predominating over the former, at other times an equilibrium established between them, and according to these different circumstances, organic and animal life alternately superior, inferior, or equal to each other.

What we observe in the long chain of animated beings, we may remark in the human species taken separately. In the one, the passions which govern them, are the principle of the greater number of their motions; the influence of animal life every moment surpassed by the organic, incessantly gives birth to actions to which the will is almost a stranger, and which, too often bring after them bitter regrets, which are felt the moment animal life resumes its empire. In the other, this life is superior to the former; hence all the phenomena relative to the sensations, perception and intelligence appear to be aggrandized at the expense of the passions which are condemned to silence by the organization of the individual. Hence the will presides; the locomotive muscles are in constant dependance on the brain, while in the preceding case it is the gastric and pectoral organs chiefly which put them in play.

The man whose constitution is the most happy and at the same time the most rare, is he who has the two lives in a sort of equilibrium, in whom the cerebral and epigastric centres exercise an equal action, in whom the passions animate, warm, and exalt the intellectual phenomena without seizing the reins, and who finds an obstacle in his judgment, which he can always oppose to their impetuous influence.

It is this influence of the passions over the actions of animal life, which constitutes what is called the character, and which, like the temperament manifestly belongs to organic life: as does also its different attributes; every thing

which emanates from it, if I may use the expression, is involuntary. Our external actions form a picture, of which the ground and design are taken from animal life, but over which organic life spreads the shades and colouring of the passions. These shades and colourings form the character.

Almost all philosophers have remarked this alternate predominance of the two lives; Plato, Marcus Aurelius, St. Augustin, Bacon, St. Paul, Leibnitz, Vanhelmont, Buffon, &c. have all recognized in us two sorts of principle; by the one we subdue all our moral actions, and the other appears to produce them involuntarily. Where is the necessity of seeking, as most of them have done, to know the nature of these principles? let us observe the phenomena, and analyze the connexions which unite them one to the other, without endeavouring to trace them to their first causes.

ARTICLE VII.

GENERAL DIFFERENCES OF THE TWO LIVES WITH RESPECT TO THEIR VITAL POWERS.

MOST physicians who have written on vital properties, have begun by seeking out their principle; they have endeavoured to descend from the study of nature to that of its phenomena, instead of ascending from what observation points out, to what is suggested by theory. *The soul of*

Stahl, the archeus of Vanhelmont, the vital principle of Barthez, and the vital power of some others, &c. by turns considered as the only centre of all the actions which bear the character of vitality, have been alternately the common base on which have rested all physiological explanations. These bases have been successively overturned, and among their ruins the facts alone remain which a rigorous experience of sensibility and mobility furnish.

Such, indeed, are the narrow limits of the human understanding, that the knowledge of first causes is almost always denied to it. The thick veil which covers them, envelops in its innumerable folds whoever attempts to rend it asunder.

In the study of nature, principles are, as some philosopher has observed, certain general results from first causes, from which arise innumerable secondary results: the art of finding out the connexion of the first with the second, belongs to the most judicious mind. To search for the connexion of first causes with their general effects is blindly to pursue a road where a thousand by-ways lead us into error.

Of what consequence, moreover, is the knowledge of these causes to us? Is there any necessity that we should know what are light, oxygen, caloric, &c. in order to study their phenomena? And can we not, without knowing the principle of life, analyze the properties of the organs which it animates? Let us do in the science of animals, as the modern metaphysicians do in that of the understanding; let us suppose the causes, and attach ourselves only to their great results.

SECTION I.

Difference of vital powers, with the physical laws.

In considering under this head the vital laws, the first view which they offer, is the remarkable difference which distinguishes them from physical laws. The one constantly varying in their intenseness, energy, and development, often pass with rapidity from the lowest degree of prostration to the highest point of exaltation, accumulate and diminish in the organs alternately, and assume, from the influence of the slightest causes, a thousand different modifications. Sleep, watching, exercise, rest, digestion, hunger, the passions, and the action of surrounding bodies, &c. expose them at every instant to numerous revolutions. The others, on the contrary, fixed, invariable, and constantly the same at all times, are the source of a series of phenomena always uniform. Compare the vital faculty of feeling, to the physical faculty of attracting, you will see that the attraction is always in proportion to the mass of rough body in which it is observed, while the sensibility changes its proportion incessantly in the same organic part and in the same mass of matter.

The invariability of the laws which govern physical phenomena, permits us to calculate all the sciences which are the object of them; while applied to the actions of life mathematics can offer no general rules. One may calculate the return of a comet, the resistance of a fluid passing through an inert canal, the swiftness of a projectile, &c.; but to calculate with Borelli the force of a muscle, with Keil the quickness of the blood, or like Jurine, Lavoisier, &c. the quantity of air which enters into the lungs, is to build a

solid edifice upon rolling sand, which must soon fall for want of a fixed foundation.

This instability of the vital powers, this facility which they have of varying more or less at every instant, impress upon all the vital phenomena a character of irregularity which distinguishes them from physical phenomena, remarkable for their uniformity: let us take for example the living fluids and inert fluids. The latter, always the same, are known when they have been once analyzed with correctness; but who can say that he knows the former after a single analysis, or even after many made under the same circumstances? The urine, saliva, bile, &c. taken indifferently from any subject, may be analyzed, and from their examination is derived animal chymistry: be it so, but this does not constitute physiological chymistry, it is, if I may use the expression, the *cadaveric* anatomy of the fluids. Their physiology is composed of the knowledge of the numerous variations they experience, according to the state of their respective organs.

The urine is not the same after a meal as after sleep; it contains in winter, principles which are foreign to it in summer, when the principal excretions are made by the skin; the simple accession of cold or heat may by suppressing the sweat and enfeebling the pulmonary exhalation, produce variations in its composition. It is the same with the other fluids: the state of the vital powers in the organs which are the sources of them, changes at every instant. These organs themselves, therefore, must experience continual changes in their mode of action, and consequently create varieties in the substances which they separate from the blood.

Who would dare to suppose himself acquainted with the nature of a fluid of the living economy, if he had not analyzed it in the infant as well as in the adult, in woman as

well as man, in different seasons, during the calm of the soul and during the storm of the passions which, as we have seen, manifestly influence its nature, and during the period of menstrual evacuations, &c.? And what would all this avail, without a knowledge of the different alterations of which the fluids are susceptible in diseases?

The instability of the vital powers has been the stumbling block to all the metaphysical calculations of the past age. The habitual variations of the living fluids, which are derived from this instability, may well be considered an obstacle no less serious to the chymical analyses of the present day.

It is easy to see, after what has been said, that the science of organized bodies should be treated in a manner entirely different from those which have for their object inorganic bodies. It would be necessary to use a different language; for the greater part of the words which we bring from physical sciences into that of the animal or vegetable economy, continually recall to us ideas which can have no connexion with the phenomena of this science.

If physiology had been cultivated by man before physics, as the latter has been before it, I am persuaded they would have made numerous applications of the former to the latter, that they would have seen rivers running by the tonic action of their borders, chrystals uniting by the excitement of their reciprocal sensibility, and planets moving because they are reciprocally irritated at great distances, &c. All this would appear very wide of reason to us who see nothing but heaviness (*pesanteur*) in these phenomena: why should we not appear equally ridiculous, when we come with this same heaviness, affinities and chymical compositions, and a language altogether founded upon those fundamental data, to the explanation of a science in which they have but a very obscure influence? Physiology would

have made much greater progress, if authors had not borrowed ideas of it from sciences which are called *accessory*, but which are essentially different from it.

Physics and chymistry approximate, because the same laws govern their phenomena; but an immense space separates them from the science of organized bodies, because an enormous difference exists between those laws and that of life. To say that physiology is the physics of animals, is to give but a very imperfect idea of it; I might say with equal propriety that astronomy is the physiology of the stars.

But this digression is already too long; let us return to the vital powers, considered with respect to the two lives of the animal.

SECTION II.

Difference of vital properties and texture.

In examining the properties of every living organ, they may be distinguished into two kinds: the one belonging immediately to life, beginning and finishing with it, or rather forming the principle and essence of it; the others are only indirectly allied to it, and appear rather to depend on the organization, than the texture of the parts.

The faculty of feeling and that of spontaneously contracting, are vital properties. Extensibility and the faculty of restoring itself when the extension ceases, are properties belonging to the texture; the latter, it is true, borrow from life an increase of energy, but they remain to the organs after life has abandoned them, the decomposition of the organs being the only term of their existence. I shall in the first place examine the vital properties.

SECTION III.

Of the two kinds of sensibility, animal and organic.

It is easy to see that the vital properties are reduced to those of feeling and moving: now each of these bears a different character, in the two lives. In organic life, sensibility is the faculty of receiving an impression; in animal life, it is the faculty of receiving an impression, and moreover, of referring it to one common centre. The stomach is sensible to the presence of food, the heart to the influx of the blood, and the excretory vessel to the contact of its appropriate fluid; but the term of this sensibility is in the organ; it does not go beyond its limits. The skin, the eyes, the ears, the membranes of the nose, and of the mouth, all the mucous surfaces at their origin, the nerves, &c. feel the impression of bodies that touch them, and then transmit it to the brain, which is the general centre of the sensibility of these different organs.

There is, therefore, an organic, and an animal sensibility: to the former appertain all the phenomena of digestion, circulation, secretion, exhalation, absorption, nutrition, &c.; it is common to the plant and to the animal; the zoophyte enjoys it in as great a degree as the most perfectly organized quadruped. From the latter flow the sensations and perception, as well as the pain and pleasure which regulate them. The perfection of animals is in proportion to the dose, if I may thus speak, of this sensibility which has been given to them. This kind does not belong to the vegetable.

The difference of these two sorts of sensitive power is particularly observable in violent deaths which come suddenly upon the animal. The animal sensibility is destroyed

at once. No trace of this faculty remains from the instant which succeeds any violent commotion, excessive hemorrhagy or *asphixia:* but the organic sensibility survives a longer or shorter time. The lymphatics still absorb; the muscle equally feels the prick that excites it; the nails and hair may still be nourished, and of course be sensible to the fluids which they imbibe from the skin, &c. It is only after a certain time, and often very long, that all traces of this sensibility are effaced, while the destruction of the other is sudden and instantaneous.

Though at first sight these two sensibilities, animal and organic, present a remarkable difference, their nature appears notwithstanding to be essentially the same; the one is probably only the *maximum* of the other. It is always the same power which, more or less intense, presents itself under different characters: the following observations are in proof of this.

There are various parts in the economy, where these two faculties are insensibly linked together, and succeed each other: the origin of all the mucous membranes is an example of it. We have the sensation of the passage of the food in the mouth and in the throat; this sensation is weaker in the beginning of the æsophagus, becomes still fainter in its middle, and disappears entirely at its end and on the stomach, where the organic sensibility only remains; the same phenomenon takes place in the urethra, in the genital parts, &c. In the neighbourhood of the skin there is an animal sensibility, which diminishes by degrees, and becomes organic in the interior of the parts.

Different stimuli applied to the same organ, may determine it alternately to both modalities of the sensibility. Irritated by acids, by highly concentrated alkalies, or by a cutting instrument, the ligaments do not transmit to the brain the strong impression which they receive. But if

they are wrung, distended or torn, a lively sensation of pain is the consequence. I have verified, by various experiments, this fact published in my *Treatise on the Membranes*, and the following is another of the same kind, which I have observed since. The coats of the arteries, sensible, as is known, to the blood which pervades them, are the *term* of their feeling which is not extended to the *sensorium:* inject into this system any foreign fluid, and the animal will testify by his cries that he feels the impression.

We have seen that the property of habit was to obtund the vivacity of feeling, to transform to indifference all the sensations of pain or pleasure; for example, foreign bodies make a painful impression on the mucous membranes in the first moments of their contact; they develop their animal sensibility; but by degrees they consume it, and the organic only remains. Thus the urethra feels the *bougie* so long as it remains in it, since its sojourn there is constantly attended with a more vigorous action of the mucous glands, whence arises a species of catarrh; but the individual has no painful consciousness of its presence, except in the first moments of its contact.

Inflammation, by increasing the organic sensibility of a part, daily transforms it into animal sensibility. Thus the cartilages, serous membranes, &c. which, in their ordinary state possess only an obscure feeling necessary to their nutrition, are then endued with an animal sensibility often more vivid than that of the organs to which it naturally belongs. And why? Because the property of inflammation is to accumulate power in a part, and this accumulation is sufficient to change the modality of organic sensibility, which differs from animal sensibility only by its smaller proportion.

After all these considerations, it is evident that the distinction above established in the faculty of feeling, rests, not upon its nature which is throughout the same, but upon the different modifications of which it is susceptible. This faculty is common to all the organs; all are endued with it, not one is insensible; it forms their true vital character; but, more or less abundantly divided in each, it gives a different modality: no one enjoys it in the same proportion; it has a thousand different degrees.

In these varieties, there is a degree above which the brain is their term, and below which the organ alone excited, receives and perceives the sensation, without transmitting it.

If, to explain my idea, I could be allowed to use a vulgar expression, I should say that, distributed in a certain dose throughout an organ, the sensibility is animal, and that with an inferior dose, it is organic;* now, this dose of sensibility is varied, sometimes by the natural order: as, the skin and nerves being superior, in this respect, to the tendons, cartilages, &c.; and sometimes by diseases; as, by doubling the dose of sensibility to the latter, inflammation equalizes them, and renders them even superior to the former. Inasmuch as a thousand causes may, every moment, increase or diminish this power in a part, so it may at every instant become animal or organic. This is

* The expressions, *dose, sum, quantity* of sensibility are very incorrect, inasmuch as they present this vital faculty in the same point of view with physical powers, with attraction, for example, and show it to us as susceptible of being calculated, &c. But for want of *specific* words for every science, it becomes necessary, in order to be understood, to borrow them from each other. It is with these expressions, as with the words, *solder, glue, unglue, &c.* which are employed for want of others, for the bony system, and which would really present very imperfect ideas, if the mind did not correct the sense of them.

the reason why authors who have made it the object of their experiments, have had such different results; and why some have found the *dura mater*, *periostium*, &c. insensible, where others have observed extreme sensibility.

SECTION IV.

Of the connexion which exists between the sensibility of each organ, and bodies which are foreign to it.

Though the sensibility be subject in every organ to continual varieties, each one appears notwithstanding to have a primitively determinate sum, to which it always returns on the cessation of these alternations of increase and diminution, somewhat as the pendulum in its different vibrations constantly resumes the place to which its weight directs it.

It is this determinate sum of sensibility in each organ, which especially constitutes its proper life; it is this which fixes the nature of its connexions with foreign bodies which come in contact with it. Thus the ordinary sum of sensibility in the urethra places it in connexion with the urine; but if this sum is augmented, as in violent erections, the connexion ceases, the canal revolts against this fluid, and suffers nothing to pass through it but the semen, which in its turn is no longer in connexion with the sensibility of the urethra in a state of non-erection.

Thus the determinate sum of sensibility in the pancreatic and *choledocus* ducts, and in those of Stenon, and Varthon, and in a word, in all the excretories, exactly analogous to the nature of the fluids which pervade them, but disproportioned to that of all others, suffers not the latter to penetrate them, undergoing spasm and contraction when

the smallest particle of them comes in contact. Thus the larynx closes itself to all bodies, but the air which is accidently introduced.

Hence the excretories, though in contact with a number of various fluids on the mucous surfaces, which pass over or remain on these surfaces, are never penetrated by any of them. Hence also the open mouths of the lacteals in the intestines, imbibe chyle only, and never absorb the fluids which are found mixed with it, fluids with which their sensibility is not in affinity.

It is not only between the different sums of the sensibility of organs and the different fluids of the body that these affinities exist; they may also be exercised between external bodies and our different parts. The determinate sum of sensibility in the bladder, kidneys, salivary glands, &c. has a specific analogy with cantharides, mercury, &c.

It might be thought that in each organ the sensibility assumes a modification, a particular nature, and that it is this diversity of nature which constitutes the difference in the affinities of the organs with foreign bodies which touch them. But a crowd of considerations proves that the difference rests, not on the nature, but on the sum, dose, quantity of sensibility, if these words can be applied to a vital property; the following are the considerations:

The absorbing orifices of serous surfaces sometimes bathe whole months in the fluid of dropsies, without imbibing any portion of it. But let the action of tonics, or the effort of nature exalt their sensibility; it places itself, if I may thus express myself, in equilibrio with the fluid, and then absorption takes place. The resolution of tumours presents the same phenomenon: so long as the powers of the part are enfeebled, the lymphatics refuse to admit the extravasated substances of these tumours. But let the sum of these powers be doubled by means of resolutives,

and the tumour will soon disappear by the action of the lymphatics.

Upon this principle rests the explanation of all the phenomena of the reabsorption of pus, blood, and other fluids, which the lymphatics sometimes take up with a sort of avidity and sometimes refuse to receive, according as the sum of their sensibility is or is not in affinity with them.

The skill of the physician, in the application of resolutives, consists in finding out the mean degree, and to restore the vessels to it, either by adding new strength or taking from them a part of that with which they are provided, according as their sum of sensibility is inferior or superior to the degree which places them in affinity with the fluids to be absorbed. Thus resolutives may be ranked, according to circumstances, with the stimulating class of remedies or with sedatives.

The whole theory of inflammation is likewise connected with the ideas here presented. It is known that the system of canals through which the blood circulates, gives birth to numerous other small vessels which admit only the serous portion of this fluid, as exhalation proves beyond a doubt. Why do not the red globules pass into them? It is not because of their disproportion of diameter, as Boerhaave believed: for if the white vessels were double or triple the size of the red vessels, the globules of this colour would not pass through them, if there was not an affinity between the sum of sensibility in these vessels, and the red globules, as we have seen that the chyme does not pass into the *coledochus*, though the diameter of this duct is much greater than that of the attenuated particles of food. Now, in the natural state, the sensibility of the white vessels being inferior to that of the red, it is evident that the affinity necessary to the admission of the coloured part, does not exist. But should any cause in-

crease the powers of the former vessels, then their sensibility rises to the same level with that of the latter; the affinity is established, and the passage of fluids before repulsed, is now admitted with facility.

This is the reason that those surfaces most exposed to the agents which increase the sensibility are also most subject to local inflammations, as is observed in the *tunica conjunctiva*, in the lungs, &c. And this is most often as I have said, the cause of that increase which transforms organic into animal sensibility, and thus causes it to transmit to the brain the impression of external bodies.

The inflammations last so long as the excess of sensibility continues; by degrees it is weakened and returns to its natural standard; then also the red globules cease to pass into the serous vessels, and resolution takes place.

It may be seen, from this, that the theory of inflammation is nothing but the natural consequence of those laws which govern the passage of fluids in their different canals; it may be conceived also how void are all those hypotheses borrowed from hydraulics, which can scarcely ever offer any real application to the animal economy, because there is no analogy between a series of inert pipes, and a succession of living ducts, each of which has an appropriate sum of sensibility which places it in affinity with their proper fluids, and repulses others, and which may by being augmented or diminished in the slightest manner, change the connexion so as to admit the fluid which they rejected, and reject that which they admitted.

I should never finish, were I to multiply the consequences of these principles in the phenomena of living man, in health or sickness. In my lectures I have treated of this subject at large as connected with the theory of diseases.

It will doubtless be asked why, in the distribution of these different sums of sensibility, nature has endowed the internal organs in so inferior a degree, while the external organs are abundantly provided with this property? And why, consequently, the digestive, circulatory, respiratory, nutritive, and absorbent organs do not transmit to the brain the impressions they receive, when all the actions of animal life suppose such a transmission? The reason of it is plain; it is because all the phenomena which ally us to neighbouring beings, must be and in fact are under the influence of the will, while all those which serve only towards assimilation, escape and of necessity must escape this influence. Now, that a phenomenon should depend on the will, it is unquestionably necessary we should have the consciousness of it; that it may be abstracted from its empire, it is necessary that this consciousness should be void.

SECTION V.

Of the two kinds of contractibility, animal and organic.

The most usual mode of motion in animal organs, is contraction. Some parts however move by dilatation: as the iris, corpora cavernosa, &c. so that the two general faculties, from which spontaneous mobility is derived, are contractibility and active extensibility, which it is necessary to distinguish from passive extensibility of which we shall speak by and by: the one belongs to the life, the other to the texture only, of the organs. But as yet too few *data* exist on the nature and modality of the motion which results from the first; and a too small number of organs present it to us, to authorize our having respect to it in these

general considerations. We shall occupy ourselves therefore with contractibility only; for extensibility, I refer to the physicians of Montpellier, who have written on it.

Spontaneous mobility, the inherent faculty of living bodies, like sensibility, presents to us two great modifications, with a wide difference between them, according as we examine it in the phenomena of the one or the other life. There is both an organic and an animal contractibility.

The one particularly under subjection to the will, has its principle in the brain, receives from it those irradiations which put it in play, ceases to exist the moment the organs in which it is observed no longer communicate with it by the nerves, constantly participates the varieties of its state, has its seat exclusively in the muscles which are called *voluntary*, and governs locomotion, the voice, the general motions of the head, thorax, abdomen, &c. The other, having no common centre, finds its principle in the moving organ itself, is independent of voluntary actions, and gives place to the phenomena of digestion, circulation, secretion, absorption, nutrition, &c.

Both, like the two kinds of sensibility, are essentially distinct in violent deaths which suddenly destroy the animal contractibility, and suffer the organic still to exercise its action for a longer or shorter time; they are also equally so in *asphixia*, an affection very much resembling death, and where the first is entirely suspended while the activity of the other remains; they are distinct also in paralyses produced artificially or by disease in a member, and in which all voluntary motion ceases, while organic motion remains unaffected.

Both kinds of contractibility are connected to the correspondent species of sensibility. The sensations of external objects put into action the animal contractibility. Be-

fore the organic contractibility of the heart can be exercised, its sensibility must have been previously excited by the influx of blood. They may be called a sequel of each other.

The connexion, however, is not the same in the two kinds of faculties. The animal sensibility may be exercised without producing as a necessary consequence the action of the analogous contractibility; there is a general affinity between sensation and locomotion; but this affinity is not actual or direct; on the contrary organic contractibility is never separated from the sensibility of the same kind. The reaction of the excretory ducts is immediately dependant on the action exercised on them by the secreted fluids: the contraction of the heart succeeds as a necessary consequence to the influx of the blood. Authors therefore have not separated these two things in their considerations, nor even in their language. Irritability designates at the same time both the sensation excited in an organ by the contact of a body, and the contraction of the organ reacting upon the body.

The reason of this difference in the affinity of the two kinds of sensibility and contractibility, is very plain: in organic life there is no intervention in the exercise of the two faculties; the organ itself is the term where sensation ends, and the principle which gives rise to contraction. In animal life on the contrary, there are between these two actions, intermediate functions, those of the brain and nerves, functions which, if interrupted, destroy the affinity.

It is to the same cause we must refer the following observation; that is, that in organic life there always exists a rigorous proportion, between sensation and contraction, while in animal life the one may be increased or diminished without the other's being affected by it.

SECTION VI.

Subdivision of organic contractibility into two varieties.

Animal contractibility is always nearly the same, in whatever part it may manifest itself; but there exist in organic contractibility two essential modifications, which would appear to indicate a difference in their nature, though there is only a diversity in the external appearance: sometimes indeed it manifests itself in an apparent manner, but at other times though it really exists, it is almost impossible to discover it by inspection.

Sensible organic contractibility is observed in the heart, stomach, intestines, bladder, &c. it exercises itself on the considerable masses of animal fluids.

Insensible organic contractibility is that, by virtue of which the excretory ducts react upon their respective fluids, the secretory organs upon the blood which comes to them, the parts in which nutrition operates on the nutritive juices, and the lymphatics upon the substances which excite their open extremities, &c. Wherever the fluids are disseminated in small masses, or where they are minutely divided, there this second kind of contractibility is displayed.

A sufficiently correct idea may be formed of both, by comparing the one to that attraction which is exercised on large aggregates of matter, and the other to that chymical affinity by which the particles of different substances unite. Barthez, in order to render plain the difference between them, compares them to a watch, whose minute-hand traverses the circumference in a manner very percep-

tible, while the motion of the hour-hand equally existing is not apparent.

Sensible organic contractibility corresponds very nearly to what is named *irritability ;* and insensible organic contractibility to what is called *elasticity* (tonicité.) But these two words appear to suppose a diversity of nature in the properties they indicate, while this diversity exists only in external appearance.

I prefer therefore to employ the common term, of *organic contractibility* to express them both, which designates their general character, that of appertaining to internal life, and of being independent of the will, and because it gives the opportunity of adding an adjective to express the particular attribute of each.

One indeed would have but very incorrect ideas of these two modalities of motion, if they were considered as resting upon different principles. The one is only the extreme of the other; they are both connected by indeterminate gradations. Between the obscure, but existing contractibility, necessary to the nutrition of the nails, hair, &c., and that displayed in the motions of the intestines, stomach, &c. there are infinite shades of transition: such as the motions of the dartos, of the arteries, of certain parts of the cutaneous organ, &c.

The circulation will serve very well to give us an idea of this gradual connexion of the two kinds of organic contractibility: it is the sensible species which presides over this function, in the heart and great vessels; presently it becomes less apparent, in proportion as the diameter of the vascular system diminishes, until at length it is insensible in the capillaries, where *elasticity* only is observable.

To consider irritability, like most authors, as a property exclusively inherent in the muscles, as being one of their

distinguishing characters from the other organs, and to express this property by a word which indicates this exclusive seat, is, I think, not to have such a conception of it as its distribution by nature would warrant.

The muscles certainly occupy, in this respect, the first rank in the scale of animated solids; they have the *maximum* of organic contractibility: but every living organ, reacts like them, though in a less apparent manner, upon the exciting cause artificially applied to them, or upon the fluid communicating with them naturally for the purpose of depositing the matter of the secretions, nutrition, exhalation or absorption.

There is nothing, consequently, more uncertain than the rule commonly adopted for determining the muscular or non-muscular nature of a part; a rule which consists in examining whether it contracts under the action of natural or artificial irritating causes.

Hence it is that the arteries have been admitted to have a fleshy coat, though they are entirely different in their organization from the muscles; and hence also the matrix has been pronounced fleshy, though innumerable marks of difference distinguish it from these sorts of substances; for the same reason the texture of the dartos, iris, &c. has been thought muscular though no resemblance is observable in them.

The faculty of contracting under the action of irritating causes, like that of feeling, is unequally divided among the organs; they enjoy it in different degrees: to consider it as exclusively proper to any particular one, is not to conceive it properly. It has not its seat uniformly in the fibrine of the muscles, as some have thought. To have life is the only condition necessary to the enjoyment of it by the fibres. Their particular texture has no influence ex-

cept as to the sum which they receive; it appears that to one sort of organic texture is assigned a certain dose, to use the expression, of contractibility, and that to another kind of texture is given another dose, &c. so that, to employ the same expressions we used in treating of sensibility, improper it is true, but the only expressions which can explain my idea, the differences in the organic contractibility of our different parts, depend on the quantity only, and not on the nature of this property: it is in this only that consist the numerous varieties of this property according as it is considered in the muscles, ligaments, nerves, bones, &c.

If some specific word must be used to express the particular mode of contraction in the muscles, this word certainly cannot be organic contractibility, but it may be that of the voluntary muscles, since they only of all our parts, move under the influence of the brain. But this property is unconnected with their texture, and comes to them only from this organ: for when they cease to communicate with it directly by the nerves, they cease also to be moved voluntarily.

This brings us to the examination of the limits placed between the two kinds of contractibility. We have seen that those which distinguish the modes of sensibility, appear to depend on the greater or less proportion of this power, that a certain dose of this property is animal, and a weaker dose organic, and that often by the simple increase or diminution of intenseness they reciprocally change their respective characters. We have seen a phenomenon nearly similar in the two subdivisions of organic contractibility.

It is not thus with the two great divisions of contractibility considered in general. The organic can never be

transformed into animal; whatever may be its exaltation, its increase of energy, it constantly retains its nature. The stomach and intestines often assume such a susceptibility of contraction, that the slightest contact produces the most violent motions in them, but these motions always preserve their type, their primitive character; the brain never regulates these irregular fits, as in the *increase* of organic sensibility it perceives impressions which would not otherwise be communicated to it.

Whence arises this difference in the phenomena of sensibility and contractibility? I cannot resolve this question in a satisfactory manner.

SECTION VII.

Extensibility and contractibility of texture.

After having presented some general reflections upon the powers which belong immediately to life, I shall now examine the properties which depend only on the texture, and organic arrangement of our parts; these are extensibility and contractibility.

These two properties mutually and reciprocally depend on each other, like the vital phenomena of organic or animal sensibility and contractibility.

Extensibility of texture, or the faculty of elongating and distending itself beyond its ordinary state, by any foreign impulse (which distinguishes it from the extensibility of the *iris*, *corpora cavernosa*, &c.) belongs in a sensible manner to a great number of organs. The *extensor* muscles assume a remarkable length in violent extensions of the limbs; the skin readily lends a covering to large

tumours; the *aponeuroses* are distended when a fluid is accumulated under them, as may be seen in ascites, obesity, &c. The mucous membranes of the intestines, bladder, &c. and the serous membranes of most of the cavities present a similar phenomenon in the fulness of their respective cavities: the fibrous membranes and the bones themselves are also susceptible of it; thus in *hydrocephalus*, the dura mater, pericranium, and bones of the cranium, and in *spima-ventosa*, *&c.* the periosteum and extremities or middle of the long bones experience a similar distension. The kidneys, brain and liver in abscesses formed within them, the spleen and lungs when a large quantity of blood penetrates their texture, the ligaments in dropsical swellings of the joints, and in a word all the organs, under a thousand different circumstances afford us proofs without number of this property which is inherent in their texture, and not precisely in their life; for so long as this texture remains uninjured, the extensibility exists, even after life has been for a long time extinct in them. Decomposition, putrefaction, or whatever changes the organic texture, is the only term of the exercise of this property, in which the organs are always passive, and subject to the mechanical influence of the different bodies which act upon them.

There is a scale of extensibility, for the different organs, at the top of which are placed those which possess the greatest degree of softness in the arrangement of their fibres, as the muscles, skin, cellular texture, &c. and at the bottom are those which are characterized by a great degree of density, as the bones, cartilages, tendons, nails, &c.

We must guard against being imposed upon, however, by certain appearances, respecting the extensibility of our parts. Thus the serous membranes which at first sight,

appear susceptible of enormous distensions, enlarge much less of themselves, than by the development of their folds, as I have elsewhere proved at large. And thus the skin which abandons the neighbouring parts for the purpose of enclosing tumours, may be thought susceptible of a much greater degree of distension than it really is, &c.

To the extensibility of texture there is a particular correspondent mode of contractibility, the character of which may be designated by the same word or by this expression, *contractibility by defect of extension;* indeed, that it may be exercised in an organ, it is sufficient that extensibility should cease to be in action.

In the ordinary state, most of our organs are maintained at a certain degree of tension, by different causes; the locomotive muscles by their antagonists; the hollow muscles by the different substances they enclose; the vessels by the fluids which circulate in them; the skin of one part by that of the neighbouring parts; the alveolar processes by the teeth which they contain, &c. But if these causes cease, contraction supervenes: cut a long muscle, and the antagonist will be shortened; evacuate a hollow muscle, it contracts itself; prevent an artery from receiving blood it becomes ligament; cut the skin, the margins of the incision separate, drawn away by the retraction of the neighbouring parts; draw out a tooth, and the alveolar process is obliterated, &c.

In these cases, it is the cessation of the natural extension, which brings on contraction; in others, it is the cessation of an unnatural extension. Thus the lower-belly contracts after *accouchement*, or the operation of paracentesis; the maxillary sinus after the extirpation of fungous excrescences; the cellular texture, after the opening of an abscess; the tunica vaginalis, after the operation for hydrocele; the skin of the scrotum, after the amputation of

a swelled testicle; and aneurismal sacs, after the evacuation of the fluid, &c.

This mode of contractibility is perfectly independent on life; like extensibility, it belongs only to the texture and organic arrangement of the parts; it receives, nevertheless, an increase of energy from the vital powers: thus the retraction of a muscle cut after death is much less than that of a muscle divided during life: so also does the skin vary under these two circumstances; but though less decided, contractibility still exists; like extensibility it has no end, but in the disorganization of the parts by decomposition, putrefaction, &c. and not in the destruction of their vital powers.

Most authors have confounded the phenomena of this contractibility, with those of insensible organic contractibility or *elasticity:* this has been done by Haller, Blumenbach, Barthez, &c. who have referred to the same principle, the retraction of distended abdominal parts, the separation of the skin or a divided muscle, and the contraction of the dartos by cold, the crispation of parts by certain poisons. styptics, &c. The first of these phenomena are owing to *contractibility by defect of extension*, which never supposes the application of irritating causes to the parts; and the second to *elasticity* which is never exercised but by their influence.

Nor have I sufficiently distinguished these two modes of contraction in my work upon the membranes; but decisive limits should evidently be established between them.

An application will render this much more sensible. Let us take an organ, in which are found all the species of contractibility of which I have heretofore spoken, a voluntary muscle, for example; by distinguishing these species in it with precision, we may form a clear and distinct idea of them.

This muscle enters into action, in the first place, by the influence of the nerves which it receives from the brain: this is animal contractibility; 2ndly, by the excitement of a chymical or physical agent applied to it, which excitement artificially produces in it a motion analogous to that which is natural to the heart and other involuntary muscles: this is sensible organic contractibility, or irritability; 3rdly, by the entrance of fluids, which penetrate every part of it for the purpose of bringing it the matter of nutrition, and which cause a motion of partial oscillation in every fibre, and in every particle of it, a motion necessary to this function, as in the glands it is indispensable to secretion, and in the lymphatics to absorption, &c.: this is insensible organic contractibility or *elasticity;* and 4thly, by a transverse section of its body, which produces a retraction of its divided ends towards their point of insertion: this is contractibility of texture, or *contractibility by defect of extension.*

Each of these species may cease individually in a muscle: cut the nerves which go to it, and there will be no more animal contractibility, but the two kinds of organic contractibility will remain. Impregnate the muscle afterwards with opium, by suffering it to penetrate its vessels, it will cease to move in toto under the impression of irritating causes; it will lose its irritability; but its *elastic* motions will still remain, produced by the influx of the blood. At length kill the animal, or rather tie all the vessels which go to the limb, the muscle will thus lose its *elastic* powers, and nothing then will remain to it but contractibility of texture, which will not cease until gangrene, the natural consequence of the interruption of vital action, shall supervene.

This example will easily serve to show the different species of contractibility in organs which are provided with a smaller number of them than the voluntary muscles, as in the heart and intestines, where there are sensible and in-

sensible organic contractibility and contractibility of texture; in the white organs, tendons, aponeuroses, bones, &c. where the sensible animal and organic contractibilities are wanting, while the insensible organic contractibility, and contractibility of texture only are present.

In general these two last are inherent in every species of organ, whereas the two first belong only to some particular organs. We should adopt therefore elasticity or insensible organic contractibility as the general character of all the living parts, and contractibility of texture as the common attribute of all the living or dead parts which are organically disposed.

This last contractibility has besides, like extensibility, &c. to which it is always proportioned, its different degrees, its scale of intenseness: the muscles, skin, cellular texture, &c. of one part; and the tendons, aponeuroses, and bones of another, form the extremes in this respect.

After all that has been said in this article, it is easy to see that in the contractibility of every organ, there are two things to be considered, namely, the contractibility or the faculty, and the cause which gives action to this faculty. The contractibility is always the same, it belongs to the organ, and is inherent in it; but the cause which produces its exercise varies particularly, and hence the different kinds of contraction, animal, organic, and that by defect of extension; so that indeed these words should be joined rather to contraction, which expresses the action, than to contractibility, which indicates only the principle of it.

SECTION VIII.

Recapitulation of the properties of living bodies.

A SUMMARY of this article on the properties of living bodies may, I think, be given in the following table, which will present them all under one view.

	CLASSES.	GENERA.	SPECIES.	VARIETIES
PROPERTIES.	I. Of Life.	I. Sensibility.	I. Animal.	
			II. Organic.	
		II. Contractibility.	I. Animal.	
			II. Organic.	I. Sensible.
				II. Insensible.
	II. Of Texture.	I. Extensibility.		
		II. Contractibility.		

I have not inserted in this table the particular motion of the iris, corpora cavernosa, &c. a motion which precedes the arrival of the blood and which is not produced by it, the dilatation of the heart, and in a word, that species of active and vital extensibility of which certain parts appear susceptible. At the same time that I acknowledge the reality of this modification of vital motion, I must avow that my ideas are not yet clear and precise respecting their con-

nexion to the other kinds of mobility, nor the differences which distinguish them.

From the properties which I have just explained, result all the functions and all the phenomena of the animal economy: there is not one which may not on a final analysis be referred to them, as in all physical phenomena we constantly meet with the same principles, the same causes, namely, attraction, elasticity, &c.

Wherever the vital properties are in activity, there is a disengagement and loss of animal heat, or *caloric*, which compose a temperature for the animal independent of that in which he lives. The word *caloricity* is improper to express this phenomenon, which is a general effect of the two great vital faculties in exercise, and which never results from one particular faculty, distinct from those. We do not say *digestionability*, *respirationability*, *&c.* because digestion, respiration, &c. are the consequences of functions resulting from common laws: and we may say the same of the production of heat.

It is under this consideration also that the *digestive power* of Grimaud presents an incorrect idea. The assimilation of heterogeneous substances to our organs, is one of the great *products* of sensibility and mobility, and not of a particular or proper power. Such also are Blumenbach's *powers of formation*, the *fixed situation* of Barthez, and the various principles admitted by a crowd of authors, all of whom have attributed to the functions and their results, denominations which indicate the laws and properties of life, &c.

The proper life of each organ is composed of the different modifications that vital sensibility and mobility undergo in each, modifications which depend inevitably on circulation and the temperature of the organ. Each one in their several sensibility, mobility, temperature, and circulation

has a particular mode of feeling, and of moving, a heat independent of that of the body, and a capillary circulation which, subtracted from the empire of the heart, only receives the influence of the tonic action of the part. But let us pass over this point of physiology, which has been so often and so learnedly discussed by other authors.

For the present, I offer only, what has just been said of the vital powers, as a view of the different modifications they experience in the two lives, as detached ideas, which will soon form the base of a much more extensive work.

I have not mentioned the various divisions of the powers of life, adopted by authors; the reader will find them in their works, and will easily comprehend the difference which distinguishes them from that which is offered. I shall only observe that if these divisions had been clear and distinct, if the words *sensibility*, *irritability* and *elasticity*, &c. had been considered by all in the same sense, we should have found in the writings of Haller, Lecat, Wyth, de Haen, and all the physicians of Montpellier, fewer disputes unprofitable to the science and fatiguing to those who study it.

ARTICLE VIII.

Of the origin and development of animal life.

If there is any circumstance which establishes a real line of demarcation between the two lives, it is doubtless the mode and epoch of their origin. One, the organic, is in action from the moment of our existence; the other, animal life, does not enter into exercise until after birth, when external objects offer to the individual which they surround, the means of connexion and relation: for, without external exciting causes, this life is condemned to necessary inaction, as with the fluids of the economy, which are the internal exciting causes of organic life, this last would be extinct. But this requires more ample discussion.

Let us see in the first place how animal life, primitively null, has its birth and development.

SECTION I.

The first order of functions of animal life is null in the fœtus.

The moment the fœtus begins to exist, is almost the same in which it is conceived; but this existence, whose sphere is daily enlarged, is not the same with that it shall enjoy when it has seen the light.

The state in which it is found, has been compared to a profound sleep; but this comparison is deceitful; in sleep,

animal life is only in part suspended; in the fœtus it is entirely extinguished, or rather has never commenced. We have in fact seen that it consists in the simultaneous, or distinct exercise of the pulse, nerves, brain, locomotive and vocal organs: now all is inactive in these different functions.

Every sensation supposes both the action of external bodies upon ours, and the perception of this action, a perception which is produced by virtue of the sensibility, which last is here of two kinds, or rather it transmits two kinds of action, the one general, the other particular.

The faculty of perceiving general impressions, considered in exercise, forms that feeling which, very distinct from the act of touching, serves to advertise us of the presence of bodies, and of their qualities, whether hot or cold, dry or moist, hard or soft, and of their other common attributes. To perceive the particular modifications of bodies, is the appendage of the senses, each of which is in a state of connexion with one species of these modifications.

Has the fœtus any general sensations? To decide this question, let us examine what impressions can exercise the touch in it. It is exposed to one habitual temperature; it swims in a fluid; in swimming about it knocks against the walls of the matrix: here are three sources of general sensations.

Let us remark, in the first place, that the two first are almost null, that it cannot have the consciousness either of the medium in which it is nourished, or of the heat which pervades it. In fact every sensation supposes a comparison between the actual and passed state. Cold is sensible to us, because we have experienced an antecedent heat; if the atmosphere was at an invariable degree of temperature, we should not be able to distinguish this

degree: the Laplander finds his well-being under a sky, where the African would experience only pain and perhaps death, if he was suddenly transported to it. It is not during the solstice, but during the equinox, that the sensations of heat and cold are most lively, because then their varieties being more numerous, cause more frequent comparisons of what we feel with what we have previously felt.

It is the same with the *liquor amnii*, as with the heat; the fœtus does not experience its influence, because the contact of any other medium is unknown to it. Before we go into a bath, the air is not sensible to us, but upon coming out of the water, the impression of it is painful; and why? It affects us then for the sole reason that it has had an interruption in its action on the cutaneous organ.

Are the shocks received by the fœtus in striking against the walls of the uterus, a more real cause of excitement than the liquor amnii or heat? At first view this would appear to be affirmed, because the fœtus being subject only by intervals to this excitement, the sensation which arises from it should be more lively. But we must remark that the density of the matrix, particularly in pregnancy, not being much greater than that of the *waters*, the impression should be less. In fact, the nearer bodies approximate in consistence, the medium in which we live, the less powerful is their action upon us. Water reduced to vapour, in ordinary fogs, only slightly affects the feeling, but in proportion as it is thickened, and farther removed from the density of the air, it is the cause of a more lively affection.

The air, therefore, for animals that respire, is the term of general comparison to which he refers all the sensations of touch. Plunge the hand into carbonic acid gas, and

the touch will not teach you to distinguish it from common air, because their density is nearly the same.

The vivacity of the sensations is in direct ratio to the difference between the density of the air, and the bodies which are the objects of the sensation. For the same reason, the measure of the sensations of the fœtus is the excess of density in the matrix over that of the liquor amnii; this excess not being very considerable, the sensations must be dull. It is thus also, that what appears of great density to us, must less powerfully affect fish, by reason of the medium in which they live.

This assertion, relative to the fœtus, will become more general if we add the following: namely, that the mucous membranes, the seat of the internal touch, as the skin is of the external touch, have not yet commenced their functions in it. After birth, continually in contact with bodies foreign to our own, they find causes of irritation in these bodies which incessantly renewed, become more powerful for the organs. But in the fœtus there is no succession of these causes; the same urine, the same meconium, and the same mucus constantly exercise their action on the bladder, intestines, pituitary membrane, &c.

We conclude from all this, that the general sensations of the fœtus are feeble, and almost null, though it is surrounded by the most of those causes which should afterwards produce them. Its particular sensations are not more active, but this depends on the absence of exciting causes.

The eye which is closed by the *membrana pupilaris*, and the nostril whose development is scarcely sketched, could not be susceptible of receiving impressions but by supposing that light and odours could act upon them. The tongue when applied against the palate is not in contact

with a body which can produce in it the sensation of taste; was it even applied to the liquor amnii, the effect would be the same, because, as we have said, there can be no sensation where there is not a variety of impression. Our saliva has some taste to another; but to ourselves it is insipid.

The hearing is not awakened by any sound; all is calm, all rests in peace in the little individual.

Here are then already, if I may thus express myself, four doors shut to particular sensations, and which will not be opened to receive them, until after birth. But we must observe that the nullity of action in these senses, is almost inevitably attended by that of the touch.

This sense is indeed especially destined to confirm the notions acquired by the others; for they are often illusive agents, while this is always the test of truth. Thus therefore, by attributing to it this use, nature subjects it directly to the will, while light, sounds and odours often strike their respective organs in defiance of us.

The exercise of the other senses precedes this, and even produces it. If a man should be born deprived of sight, smell and taste, how is it conceivable that the touch could have place in him?

The fœtus resembles this man: it has wherewithal to exercise the touch, its hands being already well developed; and whereupon to exercise it, within the walls of the uterus: it remains notwithstanding in a constant nullity of action, because neither seeing, feeling, tasting nor hearing, it is not driven by any thing to exercise the touch. Its members are to it, what the limbs and branches are to a tree, they communicate no impression of the bodies which they touch, and with which they are interwoven.

I must observe, by the way, that there is a great difference between the *feeling** and the touch, hitherto confounded by physiologists, namely, that the will always directs the impressions of the latter, whereas those of the former, which gives us the general sensations of heat or cold, wet or dry, &c. are constantly out of the reach of its influence.

We may therefore establish, generally, that that portion of animal life which constitutes the sensation, is nearly void in the fœtus.

* (*Tact.*) There is no single word by which the precise meaning of our author can be rendered in English, unless we attach distinct and separate significations to the terms *touch* and *touching;* which have been heretofore indiscriminately used to express the same sensation, not only in common language, but by physiologists. Johnson and Walker define touch, both as "the *sense* of feeling," and "the *act* of touching." Haller also uses it in this twofold sense. But if we admit this to be an error, it will be easy for us to express the distinction really existing between the two sensations. The touch I understand to be that sensation communicated to the brain by the contact of bodies against our will; the sense of touching on the contrary, I understand as having its seat chiefly in the papillæ of the fingers, and in the point of the tongue, and of course always under the direction of the will. In feeling the pulse we have an example of both these sensations: the sense of touching is exercised by laying our fingers on the artery; this we may do or not do, as the will directs us. But it is the pulsation in this artery; the strokes of which are felt against the ends of the fingers, that communicates the sensation of *touch;* we feel that something touches us, but this feeling cannot be regulated by the will, for so long as we continue to hold the fingers in contact with the artery, so long will the idea that something touches them be communicated to the brain, in defiance of our will to the contrary. The sense of *touch*, resides in almost every part of the body, internally as well as externally; the sense of *touching* is confined to the ends of the fingers, tongue, and some few other parts of the body. According to what has been said, the word touch has been improperly used in the text; and the reader is requested to observe that when the two sensations are spoken of in future, the terms of expression as used in this note shall be adopted. T

This nullity in the action of the senses, supposes it also in that of the nerves which go to them, and of the brain from which they come; for to transmit is the function of the former, and to perceive, that of the latter. Now, without objects of transmission and perception, these two actions cannot have place.

Memory and imagination are derived immediately from perception; from one of these three faculties, judgment results; and from the last, the will.

All this series of faculties then which succeed, and are the result of each other, has not yet commenced in the fœtus, because of its having yet had no sensations. The brain is in readiness; it possesses all that is requisite for action; it is not excitability, but the excitement that is wanting.

It follows hence, that all the first division of animal life, namely, that which has relation to the action of external bodies upon ours, is not unfolded in the fœtus; let us examine if the same is the case with the second division, or that which relates to the reaction of our body upon others.

SECTION II.

Locomotion exists in the fœtus, but it belongs in it to organic life.

After seeing the close connexion there is in animals between these two divisions, between the sensations and all the functions which depend on them on the one part, locomotion and voice on the other part, we are led to believe that the former are in direct relation to the latter, and that voluntary

motion always increases or diminishes in proportion as the *sentiment* of what surrounds the animal increases or diminishes in him. For if the *sentiment* furnishing the materials of the will be wanting, the motions which depend thereon must be wanting also. From one induction to another it might thus be proved that the voluntary muscles must be inactive in the fœtus, and that consequently no kind of motion in the trunk or members could have place in it.

It moves, however, notwithstanding; and sometimes very powerful thumps are the result of its motions. If it produces no sound, it is not that the muscles of the larynx remain passive; but because the medium necessary for this function is wanting. How is the want of motion of the first part of animal life to be reconciled, with the activity of the second? What follows will explain:

We have seen, in speaking of the passions, that the locomotive muscles, that is to say those of the limbs, trunk, and in a word all the different motions of the heart, stomach, &c. were put into action in two ways; 1st, by the will, and 2nd, by sympathy. This last mode of action takes place where, because of the affection of an internal organ, the brain is affected also, and determines the motions then involuntary in the locomotive organs: thus a passion bears its influence on the liver; the brain excited sympathetically, excites the voluntary muscles; then it is in the liver that the *principle* of their motions really exists, which motions are, in this case, of the class of those belonging to organic life: so that these muscles though always put in motion by the brain, may notwithstanding in their functions alternately belong both to the one and to the other life.

It is easy, at present, to form a conception of the locomotion of a fœtus; it is not in it, as it will be in the adult, a portion of animal life; its exercise does not suppose a

preexisting will to direct and regulate its actions; it is an effect purely sympathetic, and which has its principle in organic life.

All the phenomena of this life succeed each other then, as we shall see, with extreme rapidity; a thousand different motions incessantly follow each other, in the circulatory and nutritive organs; the action of the whole is very energetic: but this activity of organic life supposes frequent influences exercised by the internal organs on the brain, and consequently numerous reactions exercised by the latter upon the muscles, which are therefore moved by sympathy.

The brain is so much the more susceptible of being affected by these sorts of influence, as it is the more developed in proportion to the other organs, and as it is passive on the score of sensations.

It may now then be easily conceived what are the motions of the fœtus. They belong to the same class with many of those of the adult, that have not yet been sufficiently distinguished; they are the same as those produced by the passions on the voluntary muscles; they resemble those of a man asleep, and who, without the agitations from a dream, moves himself with more or less force. There is nothing more common, for example, than violent movements, in sleep that succeeds painful digestion: the stomach being then in brisk action, acts upon the brain, and this last throws into action the locomotive muscles.

Under this respect we must distinguish two kinds of locomotion in sleep: the one, in a manner voluntary, produced by dreams, is a dependance of animal life; the other, the effect of the influence of the internal organs, has its principle in organic life, to which it belongs; this last is precisely the locomotion of the fœtus.

I might find various other examples of involuntary, and consequently organic movements, executed in the adult by the voluntary muscles, and therefore proper to give an idea of those of the fœtus; but these will suffice. Let us remark, however, that the organic motions, as well as the sympathetic affection of the brain, which is their source, by degrees dispose this organ and the muscles, the former to the perception of sensations, and the latter to the motions of animal life, which commence after birth.

After what has been said in this article, we may, I think, confidently conclude, that in the fœtus animal life is null, and that all the acts attached to this age, are in a dependance on organic life. The fœtus has nothing in its phenomena which can particularly characterize the animal; its existence is the same as that of the vegetable; its destruction cannot be considered that of an animated being, but of a living being only. In the cruel alternative, therefore, of being compelled to sacrifice it, or to expose the mother to an almost certain death, the choice should not be for a moment doubtful.

The crime of destroying its life is more relative to animal than to organic life. It is the being who feels, who reflects, who wills, who performs voluntary actions, and not the being who respires, digests, is nourished, and has circulation, secretions, &c. whom we regret, and whose violent death is accompanied with all those horrible images under which homicide is painted to our minds. In the series of animals, in proportion as the intellectual functions decrease, the painful feeling which the sight of their destruction causes us, is gradually weakened; it becomes extinct when we come to vegetables, which possess organic life only.

If the blow of an assassin, which terminates the existence of a man, destroyed only this life in him, and the other was

left to keep up the exercise of all those faculties which establish our connexion with surrounding beings, the blow would be looked upon with an indifferent eye; it would excite neither commiseration for the victim, nor horror for the murderer.

Why does a large wound, attended with a copious flow of blood excite alarm? it is not because it stops the circulation, but because the swoon which is soon the consequence, suddenly destroys all the ties which attach our existence to surrounding objects.

SECTION III.

The development of animal life; and EDUCATION *of its organs.*

THE infant commences a new mode of existence the moment he leaves the womb of his mother. Various functions are added to organic life, the results of which now become more complicated and multiplied. Animal life enters into exercise, and establishes between the little individual and surrounding bodies, relations before unknown. Every thing in him puts on a different mode of being; but in this remarkable epoch of the two lives, when the one is doubly increased, and the other but commences, both assume a distinct character, and the improvement of the first does not follow the same laws as the development of the second.

We shall remark presently that the organs of internal life attain perfection all at once; that from the instant they begin to act, they do it with as much precision as during all the rest of their activity. On the contrary, the organs of external life require a sort of *education;* they arrive only by slow degrees to that perfection, which their exercise in

the end presents to us. This important difference deserves profound examination: let us commence with animal life.

Take a cursory view of the functions of this life, which, at birth, starts out entire from the nought in which it was buried; you will observe a slow and gradual progress in their development; and you will see that it is by insensible degrees, and by a real education, that the organs are brought to exercise themselves with accuracy.

The sensations, at first confused, trace only general images to the infant, the eye has merely the sensation of light, the ear of sound, the taste of savour, and the nose that of odour; nothing is yet distinct in these general affections of the senses. But habit insensibly damps these first impressions: and then particular sensations arise; the great differences of colours, sounds, odours, and savours, are perceived, by degrees the secondary differences are perceived also; and after a certain time the infant has learned by exercise, to see, hear, taste, feel and to touch.

Such is the case with the man who, shut up for a long time in profound darkness, is at first only dazzled by the light, and gradually acquires a distinguishing view of the objects which reflect it. The same also, as I have before said, with one before whom is displayed for the first time, the magic spectacle of our ballets; he perceives at first sight something in the whole which charms him, but arrives only by degrees to the separate enjoyment of the dance, music, decorations, &c.

It is with the education of the brain, as with that of the senses; all the acts depending on its action only gradually acquire that degree of precision to which they are destined: perception, memory, and imagination, faculties that are always preceded and determined by the sensations, are enlarged and extended in proportion as new excitements call

forth their exercise. The judgment, of which they are the triple base, at first only irregularly associates ideas themselves irregular; soon a greater degree of perspicuity distinguishes its acts; and at last they become clear and precise.

The voice and locomotion present the same phenomenon; the cries of young animals present at first a sound unformed and without any character; age modifies them by degrees, and it is not until after frequently repeated exercises, that they acquire that consonance peculiar to each species, and by which the individuals of the same species are never deceived, particularly during the season of their amours. I do not mention speech; as it is too evidently the fruit of education.

Look at a new born animal, in his multiplied movements; his muscles are in constant action. As every thing is new to him, every thing excites him to motion; he wishes to touch every thing; but neither progression, nor station yet have place in these numberless contractions of the locomotive muscular organs: it is necessary that habit should teach him to compare one contraction with another, in order to produce this or that motion, or to take this or that attitude. Until then he staggers, reels and falls at every instant.

No doubt the inclination of the basin in the human fœtus, the disposition of its femurs, the want of inflexion in its vertebral column, &c. render it but little proper to *station*, so soon after birth; but to these causes is certainly also joined the want of exercise. Who does not know that if a limb is left a long time motionless, it loses the habit of moving, and that when it is afterwards wished to use it, a sort of new education is necessary to teach the muscles precision of motion? One who should be condemned to silence for a long space of time, would certainly

experience the same embarrassment when he should desire to break it, &c. We may conclude then from these different considerations, that we must learn to live *from without*, that external life becomes daily more perfect, and that it needs a kind of apprenticeship, to what nature has taken on herself, with respect to internal life.

SECTION IV.

Influence of society upon the education of the organs of animal life.

Society exercises a remarkable influence upon this species of education of the organs of animal life; it enlarges the sphere of action of some, abridges that of others, and modifies the whole.

I observe in the first place, that society almost always gives to certain organs a degree of perfection, which is not natural to them, and which particularly distinguishes them from the others. Such indeed is the nature of our occupations, in our present customs, that that by which we obtain our living, almost always exercises one of these organs more particularly than all the rest. The ear of the musician, the palate of the cook, the brain of the philosopher, the muscles of the dancer, and the larynx of the singer, &c. have, besides the general education of external life, a particular education, that frequent exercise perfects.

The occupations of mankind, under this respect, might be divided into three classes. The first would comprehend those which put the senses particularly in play: as painting, music, sculpture, the arts of the perfumer, cook, and in a word all those that are destined to charm the

sight, hearing, &c. In the second, would be arranged those occupations in which the brain is chiefly exercised: as poetry, the sciences, &c. Those occupations which, like dancing, riding, and all the mechanical arts, throw the locomotive muscles into action, would form the third class.

Every occupation of man then employs in almost constant activity some particular organ: the habit of acting, we have observed, perfects the action: the ear of the musician hears in a harmony, and the sight of the painter discovers in a picture, what a common ear or eye would suffer to escape observation; and very often this perfection of action is accompanied by an excess of nutrition in the exercised organ. This may be observed in the muscles of the arms of boxers, in the inferior limbs of dancers, and the muscles in the face of buffoons, &c.

I have said, in the second place, that society contracts the sphere of action of several external organs. Indeed in proportion as one organ is always more occupied in our social habits, the rest are more inactive: but the habit of not acting impairs them, as has been said; they appear to lose in aptitude, what is gained by the one frequently exercised. An observation of society would afford proofs of this at every moment.

Observe the man of science who, in his abstract meditations is constantly exercising his internal senses, and who, passing his life in the silence of the closet, condemns his external and locomotive organs to inaction; observe him accidentally in the exercise of the body, you will smile at his awkward and clumsy air. The sublime conceptions of his mind will astonish; at the same time that the heaviness of his movements amuse you.

Examine on the contrary the dancer who, by his light steps appears to bring before our eyes all the seductive charms of the smiles and graces which are presented to our imagination in fable; you would suppose that profound meditations of mind had produced this happy harmony of movements: but converse with him, and you find him as astonishingly deficient in that respect as he was surprizing in external appearance.

The man of observation in society will find frequent occasion to make similar remarks. You will seldom or never see the perfection of action in the locomotive organs coincident with that of the brain or senses, and on the other hand it is extremely rare to find the former very apt in their respective functions when the latter possess considerable energy in theirs.

SECTION V.

Laws of the education of the organs of animal life.

It is manifest then that society partly inverts the natural order of the education of the organs of animal life, and that it distributes irregularly to its different organs, a perfection which without it they would enjoy in a more uniform, though still unequal proportion.

A determinate *sum* of force or powers, has been spread throughout this life generally: now this sum must always remain the same, whether its distribution has been equal or unequal; consequently the activity of one organ necessarily supposes an inaction in the rest.

This truth naturally teaches us this fundamental principle of social education, namely, that man should never apply

himself to several studies at once, if he wishes to succeed in any. Philosophers have already often repeated this maxim; but I doubt whether the moral reasons upon which they have founded it, are worth this physiological observation which proves it to demonstration, namely, that to augment the powers of one organ, it is absolutely necessary they should be diminished in the others. For this reason I shall esteem it not useless to enlarge upon this observation, and to support it by a considerable number of facts.

Hearing, and above all the sense of *touching*, acquire in the blind man a degree of perfection that we should think fabulous, if daily observation did not establish its reality. The deaf and dumb possess an accuracy in their sight, to which those who have the exercise of all their senses are strangers. The habit of establishing but few relations between external bodies and the senses, enfeebles the ecstasies of the latter, and gives to the brain such force of contemplation, that it would appear every part of animal life in them slept save this organ.

But where is the necessity of seeking in extraordinary facts for the application of a law, which every minute's observation of the animal in health will present to us.

Examine in the series of animals the relative perfection of each organ, and you will find that when one excels, the others are less perfect. The eagle with its piercing eye, has but an obscure sense of smelling; the dog, which is remarkable for the fineness of this last sense, has the first in a smaller degree; the hearing predominates in the owl, the hare, &c.; the bat is remarkable for the precision of its sense of touching; the action of the brain is predominant in monkies, and vigour of locomotion in carnivorous animals, &c.

Every species then has one division of its animal life which excells over the others, the latter being proportionately less developed; you will not find one where the perfection of one organ does not appear to be acquired at the expense of the rest.

Man has in general, abstracted from all other consideration, the hearing more perfect than any of the other senses, and this is consonant to the natural order, because the speech which is constantly exercising the ear, acts as a permanent cause of activity, and of consequent perfection in it.

It is not only in animal life that this law is remarkable; organic life in all its phenomena is almost constantly subject to it. An affection in one kidney, doubles the secretion of the other. To the obliteration of one of the parotids, in the treatment of salivary fistulæ, an energy of action succeeds in the other so great that it alone fulfils all the functions of both.

Observe what happens during the process of digestion; each system is then successively the seat of an increase of vital powers which abandon the others in the same proportion. The moment after the entrance of food into the stomach, the action of all the gastric viscera is increased; the powers centred in the epigastrium, abandon the organs of external life. Hence, as various authors have observed, that lassitude, weakness of the senses to receive external impressions, that disposition to sleep, and that facility of the teguments to grow cold, &c.

The gastric being finished, vascular digestion succeeds to it; the chyle is introduced into the circulatory system, there to undergo the influence of this system, and that of respiration: both then become a more distinct focus of

action; the vital powers are transported thither; the pulse is raised; the motions of the thorax quickened, &c.

Next the glandulous, and then the nutritive system enjoy a superiority in the state of their vital powers. In fine, after they have been thus successively displayed in all, they return to the organs of animal life; the senses resume their activity, the functions of the brain their energy, and the muscles their vigour. Whoever has reflected upon what he has experienced after a more than usual repast, will be readily convinced of the truth of this remark.

The whole of the functions represent then a kind of circle, one half of which belongs to organic and the other half to animal life. The vital powers appear to pervade these two halves successively: when they are found in one, the other remains nearly inactive: somewhat as the two portions of the globe appear alternately to languish or be reanimated according as the sun accords or refuses them its beneficent rays.

If other proofs are required of this unequal subdivision of the powers, examine nutrition; it is always more active in an organ that enjoys more life than the others. In the fœtus the brain and nerves, after birth the inferior limbs, the genital parts and breasts at the age of puberty, &c. appear to grow at the expense of the other parts where nutrition is less decided.

In diseases, inflammations, spasms, spontaneous hemorrhages, &c.: if one part becomes the seat of a more energetic action, life and power decrease in the others.

Who does not know that the practice of medicine is partly founded upon this principle, which directs the use of cupping, musk, vesicatories, rubefacients, &c.?

After these numerous considerations, we may lay it down as a fundamental law of the distribution of vital

powers, that when they are increased in one part they are diminished in all the rest of the living economy; that the sum is never augmented, but that they are successively transported from one organ to another. With this general datum, it is easy to see why man cannot perfect all the parts of animal life at the same time, and consequently why he cannot excel in all the sciences at once.

Universality of knowledge, in the same individual, is a chimera; it is repugnant to the laws of organization, and if history affords us instances of some extraordinary geniuses, who have shed an equal lustre upon several sciences, they are so many exceptions to these laws.

Who are we, to dare to expect perfection in many things, who most frequently miss it in one alone?

If it was permitted us to unite together several occupations, they would, doubtless, be those which are most analogous in the organs which they call into action, as those which relate to the senses, those which exercise the brain, and those which call forth the action of the muscles, &c.

By thus restraining ourselves in a more narrow circle, we might more easily excel in several parts; but here again the secret of being superior in one, is to attempt nothing more than mediocrity in the others.

Let us take for example, those sciences which require an exertion of the functions of the brain. We have seen that these functions relate particularly 1st, to memory, which directs us in nomenclature, 2nd, to imagination, which presides over poetry, 3rd to attention, which is more especially called forth in calculations, and 4th, to judgment, whose dominion embraces the science of reasoning: now none of these different faculties or operations can be developed or extended but at the expense of the rest.

Why does not the habit of reciting the beauties of Corneille and other dramatic authors enlarge the mind of the actor and give him an energy of conception above that of the vulgar? This is sometimes, no doubt, owing to the natural disposition, but it depends also upon this, that in the actor, memory, and the faculty of imitating are more especially exerted, and that the other faculties of the brain, are robbed, to use the expression, to enrich these two.

When I see a man attempt all at once to display his expertness in chirurgical operations, his profound judgment in the practice of physic, the extent of his memory in Botany, and the force of his attention in metaphysical contemplations, &c. he appears to me to resemble a physician who in order to cure a disease, to expel, according to the ancient expression, the morbific humour, endeavours to increase all the secretions at the same time, by the simultaneous use of sialagogues, diuretics, sudorifics, emmenagogues, and medicine to stir up the bile, pancreatic, and mucous juices, &c.

Would not the slightest acquaintance with the laws of the animal economy suffice to teach this physician, that one gland never pours out a greater quantity of any fluid, but when the others pour out less, that one of these medicines destroys the effect of the other, and that we often obtain nothing by asking of nature too much? The same may be said to the man who wishes that his muscles, brain, and senses should acquire a simultaneous perfection, and who attempts to double and triple his means of relation, when nature has decreed that where additional degrees of force are required for any of the organs, it should be subtracted from the others, but that the sum total of vital powers should never be increased.

To make one organ superior to the others, it is necessary to condemn these others to inaction. Men are deprived of their genital organs, to change their voice; it is well the barbarous idea of rendering them blind has never been adopted, to make them musicians, since it is known that blind men, not being called off by the exercise of sight, give greater attention to that of hearing. A child that should be destined to the profession of music, and that should be removed from every thing which could affect the sight, smelling, &c. that nothing might attract his attention but harmonious sounds, would, *cæteris paribus*, no doubt make a much more rapid progress.

It is therefore certain that our superiority in any one of the sciences, is in proportion to our inferiority in all the others, and that this general maxim, which has been established as a proverb by most of the ancient philosophers, but which most of our modern philosophers endeavour to invert, has for its foundation one of the grand laws of the animal economy, and will remain as immutable as the base upon which it rests.

SECTION VI.

Duration of the education of the organs of animal life.

The period, to which the education of the organs of animal life is prolonged, is too much influenced by circumstances to be determined; but what is remarkable in this education, is that every different age appears to be allotted for the perfecting certain organs in particular.

In infancy the senses are especially educated; every thing appears to concur to the development of their functions. Surrounded by objects which are new to him the

infant seeks to know every thing; those organs which establish the relations between him and what environs him, are held, if I may thus express myself, in continual erection: thus whatever relates to sensibility is found to be very distinct in the infant. The nervous system, compared to the muscular, is proportionably more considerable than in the following ages, while in the sequel most of the other systems predominate over this. It is well known, infant subjects are always chosen, to have a good view of the nerves.

To the education of the senses is necessarily connected the perfecting of the functions of the brain, which have relation to perception.

In proportion as the sum of the sensations is increased, memory and imagination begin to enter into activity. The age succeeding infancy is that of the education of those parts of the brain which have relation to these: at this time there are, on the one hand, a sufficient number of antecedent sensations, to admit of the one's being employed in retracing them to us, and the other in finding the illusory shadows it presents to our minds. On the other hand, the feeble activity of the judgment, at this epoch, favours the energy of action in these two faculties: thus also the revolution which the age of puberty brings about, the new tastes that it inspires, and the desires it creates, enlarge the sphere of the second.

When perception, memory, and imagination have been perfected, or when their education is finished, that of the judgment commences, or rather becomes more active; for from the moment it has materials, the judgment is in exercise. At this period the functions of the senses, a part of those of the brain have nothing more to acquire: all the powers are concentered for the purpose of perfecting the latter.

After these considerations it is manifest that the first portion of animal life, or that by which external bodies act upon us, and by which we reflect this action, has in each age a division which is formed and enlarged; that the first age is that of the education of the senses; that the second is directed to the perfection of imagination and memory; and that the third relates chiefly to the development of the judgment.

We should never therefore choose that age in which the senses are in their greatest activity, for the study of sciences which require an exertion of the judgment: we should follow in our artificial education the same laws which govern the natural education of the external organs. We should apply the infant to drawing, music, &c. the youth to the sciences of nomenclature, and to the fine arts over which imagination holds its empire; the adult to accurate sciences, to those which demand a reasoning upon facts. The study of logic and the mathematics terminated the education of the ancients: this was one advantage among its many imperfections.

As to the second portion of animal life or that by which the animal reacts upon external bodies, infancy is characterized by the number, frequency and feebleness of its motions, adult age by their vigour, and youth by a mixture of both. The voice does not follow these proportions: it is subject to particular influences which arise from the genital organs.

I shall not stop to consider the different modifications produced in animal life, by climate, seasons, sex, &c. So many authors have discussed these questions, that I can hardly add to what they have said.

In speaking of the laws of education in the organs of external life. I have supposed these organs to be in a state

of complete integrity, possessing all the means of perfection, and enjoying all the necessary power of texture; but if their original texture is feeble, delicate and irregular; if any defects of conformation are found in them, then these laws could have but an imperfect application to them.

Thus the habit of judging cannot rectify the judgment, if the brain badly constituted, should present an inequality of strength and conformation in its two hemispheres; and thus the frequent exercise of the larynx, locomotive muscles, &c. can never correct the irregularity of action which is produced in them by an irregularity of conformation, &c.

ARTICLE IX.

OF THE ORIGIN AND DEVELOPMENT OF ORGANIC LIFE.

WE have just seen that animal life, inactive in the fœtus, is not developed until birth, and that it is governed entirely by particular laws in its development: organic life, on the contrary, is in action almost at the instant the fœtus is conceived; it is that which commences its existence. When organization is apparent, the heart throws out the blood into every part, which carries to them the materials of nutrition and growth; it is the first part formed, and the first in action; and as all organic phenomena are under

a dependance on it, in the same manner that all those of animal life are under the control of the brain, it may be conceived how the internal functions are successively put into action.

SECTION I.

Of the mode of organic life in the fœtus.

NEVERTHELESS the organic life of the fœtus is not the same with that of the adult. Let us examine wherein consists the difference, considered in a general point of view. We have said that this life results from two great orders of functions, one of which, namely, digestion, circulation, respiration and nutrition, is incessantly assimilating to the animal those substances which nourish him; the other order, exhalation, the secretions and absorption, carries off the heterogeneous substances, so that this life is a constant circle of creation and destruction: in the fœtus this circle is peculiarly contracted.

In the first place the functions which assimilate are much less numerous. The particles before they arrive at the organs they are destined to nourish, are not submitted to so many operations; they penetrate into the fœtus, after having been already sufficiently acted upon, by the digestion, circulation and respiration of the mother. Instead of traversing the whole apparatus of digestive organs, which appear entirely inactive at this age, they enter all at once into the circulatory system; and the rout they there pass through is shorter. It is not necessary they should successively go to receive the influence of respiration;

and in this respect, the fœtus of *mammiferous** animals, in its preliminary organization, bears a close analogy with adult reptiles, in which a very small portion of blood passes into the pulmonary vessels, after leaving the heart.†

The nutritive particles, therefore, pass almost directly from the circulatory system into that of nutrition. The general process of assimilation is consequently much more simple, much less complicated at this than at the succeeding age.

* In adopting this word, I have only followed the example of our author, who in more instances than the present has thought himself authorized to create new words, particularly where their meaning cannot be misunderstood, in order to avoid the circumlocution which would be otherwise necessary to express his ideas. I trust it is hardly requisite to say, I have compounded this *word* of *mamma*, a teat or breast, and *fero* to bear. T.

† I am persuaded that much light might be thrown on the theory of the fœtus which is yet very obscure, by that of animals somewhat similar in their organization. For example in the frog, in which but little blood passes through the lungs, the heart is a simple organ, with one auricle and ventricle only: there is a communication, or rather a continuity between the venous and arterial systems, while in mammiferous animals the vessels which carry red blood do not communicate with those which carry the black, unless perhaps by the capillaries.

In the fœtus also the heart is a simple organ, forming notwithstanding its partition only one cavity, whereas after birth it is double. The venous and arterial blood are mixed together at this period, as in reptiles, &c. Now, I shall prove, farther on, that in the infant who has respired, this mixture of the blood would prove mortal, that black blood circulating in the arteries would very soon cause asphixia in the animal. Whence then arises this difference? We cannot study it in the fœtus; it will be necessary perhaps to look for it in frogs, salamanders and other reptiles which, from their organization, can remain a long time deprived of air, without perishing, a phenomenon which still more nearly allies them to mammiferous animals living within the womb of the mother. These very important researches must still remain incomplete, so long as a correct history of respiration is wanting.

In another respect, the functions which are constantly decomposing our organs, those which carry off the substances which have become foreign, and even destructive to their texture, after having formed a part of them, are at this period in a state of almost complete inaction. Pulmonary exhalation, sweat, perspiration, &c. have not yet commenced in their respective organs. All the secretions, those of the bile, urine, saliva, &c. furnish only a very small quantity of fluids in proportion to what they give afterwards; so that there is a reflux into the system of nutrition of almost all that portion of the blood which they, as well as the exhalations, expend in the adult.

The organic life of the fœtus therefore is remarkable, on the one hand, for an extreme promptitude in assimilation, a promptitude resulting from the small number of functions engaged in the process, and on the other hand, for an extreme tardiness in *dis-assimilation*, a tardiness produced by the feeble action of the different functions which are the agents of this great phenomenon.

It is easy, after the preceding observations to conceive the astonishing rapidity which characterizes the growth of the fœtus, a rapidity which is manifestly out of all proportion with that of any other period. Indeed, having but few or no emunctories, to stay the progression of the nutritive matter, every thing appears to concur to force it on towards those parts it is intended to support.

To the great simplicity of assimilation in the fœtus, we may add the great activity of the organs employed in it, an activity which proceeds from the more considerable sum of vital powers which they then have in common. The whole which belongs to the economy appears in fact to be concentered in the two systems, of circulation and nutrition; those of digestion, respiration, the secretions

and exhalation having but little exercise, enjoy them only in a small degree.

If we observe now that the organs of animal life, condemned to a necessary inaction, are the seat only of a very small portion of the vital powers, and that the surplus is then thrown back upon organic life, it will be easy to conceive how almost the whole of the powers which are afterwards divided among all the systems generally, are then concentered in those that serve to compose and nourish the different parts of the fœtus, and that consequently all the functions connected with nutrition and growth in the fœtus are distinguished by an energy totally foreign to every other period.

SECTION II.

Development of organic life after birth.

Having left the womb of the mother, the fœtus experiences a remarkable increase in its organic life: it becomes more complicated; its extent becomes almost double; many functions which before had no existence, are then added to it; and those which had existence are improved. Now, in this remarkable revolution, a law altogether contrary to that which regulates the development of animal life, is observed.

The internal organs which then enter into exercise, or which increase their action much, have no need of education; they all at once attain a degree of perfection to which those of animal life arrive only by the habit of frequent action. A single glance at the development of this life, will suffice to convince us of this.

At birth digestion, respiration, &c. a great part of the exhalations and absorptions begin all at once to be exercised: now, after the *elaboration* in the stomach, of the first milk sucked by the infant, and after the exhalants of the lungs and skin have thrown out some portion of their respective fluids, the organs of respiration, digestion and exhalation, play with a facility equal to what they will ever enjoy thereafter.

At this time also the glands which slept, as it were, which poured out only a very small quantity of fluid, are roused from their torpor to receive the excitement of the different bodies at the extremities of their excretory ducts. The passage of the milk at the extremity of the canals of Sténon and Warthon, of the chyme at the end of the choledocus and pancreatic ducts, the contact of air on the orifice of the urethra, &c. arouse the salivary glands, liver, pancreas, kidney, &c. The air on the internal surface of the trachea arteria and nostrils, and the food on that of the digestive passages, &c. irritate the mucous glands in these different parts, which enter into action. The excretions also, which until now had been suspended on account of the small quantity of fluid separated by the glands, commence.

Consider these various phenomena, and you will find that they are all successively executed with precision; and you will find also that the different organs concerned in them, require no sort of education.

Why is there this difference in the development of the two lives? I shall not seek to explain it; but shall merely observe that for the same reason that the organs of internal life, at the period of their development, receive no additional perfection from exercise and habit, and that they attain at their entrance into activity that degree of preci-

sion which they are ever afterwards to possess, no one of them is susceptible of acquiring over the others any degree of superiority, as we have observed to be the case in animal life.

Nevertheless there is nothing more common than a predominance of one system of organic life over the others; sometimes the vascular and sometimes the pulmonary system, and often the whole of the gastric organs, the liver in particular, are superior to the others in their action, and hence give a peculiar character to the temperament of the individual. But this proceeds from another cause: it is from the primitive organization, structure, and conformation of the parts, that this superiority arises; it is not the fruit of exercise, as in animal life. The fœtus in the womb, and the infant after birth present this phenomenon in a degree as real, though not so apparent, as in the succeeding ages.

For the same reason the debility of a system of the internal functions depends always, either on the original constitution, or upon some accidental morbid affection, which wears out the organic *springs* of this system, while those of the others remain untouched.

This, therefore, is the grand difference in the two lives of the animal, with respect to the inequality of perfection in the different systems of functions, from which each is derived; namely, that in the one the predominance or inferiority of one system, relatively to the rest, depends almost always upon its greater or less activity, and upon its habit of acting or not acting; that in the other, on the contrary, this predominance or inferiority are immediately connected to the texture of the organs, and never to their education.

This explains why the physical temperament and moral character are never susceptible of alteration by education, which so wonderfully regulates the acts of animal life; for, as we have seen, they both belong to organic life.

The character is, if I may thus express myself, the physiognomy of the passions; as the temperament may be said to be, of the internal functions: now, both these remaining constantly the same, and having a direction that habit and exercise never discompose, it is manifest that temperament and character must be also withdrawn from the influence of education. It may moderate the influence of the second, perfect the judgment and reflexion so as to render their empire superior to its own, and strengthen animal life, to the end that it may resist the impulsions of the organic. But to endeavour by it to alter the nature of the character, to restrain or animate the passions of which it is the habitual expression, or to enlarge or contract their sphere, would be as useless as the attempt of a physician to elevate or abase, during life, the ordinary contractile power of the heart in a state of health, or to hurry on or slacken the motion which is natural and necessary, to the action of the arteries, &c.

We might observe to this physician, that the circulation, respiration, &c. are not at all under the dominion of the will; that they cannot be regulated by man, without passing to the state of disease, &c. The same observation might be made to those who think that the character and passions are to be changed, since these are the result of the action of all the internal organs, or at least they have their seat more especially in them.

ARTICLE X.

OF THE NATURAL END OF THE TWO LIVES.

WE have just seen that the two lives of the animal begin at periods widely separated from each other, and that they are developed according to absolutely inverse laws. I shall now endeavour to show that they terminate also in a different manner, that they cease their functions at very distinct times, and that they present, when they do finish, characters as different as during the whole duration of their activity. I shall here have regard only to natural death; whatever relates to accidental causes, shall be the subject of the second part of this work.

SECTION I.

Animal life is the first to cease in natural death.

NATURAL death is remarkable, in that it terminates almost entirely animal life, long before the organic has ceased to exist.

Observe the man who sinks under extreme old age: he dies gradually; his external functions cease the one after the other; all his senses are closed in succession; the ordinary causes of sensation pass over them without affecting them.

The sight becomes dim, obscure, and at last ceases to transmit the images of objects: this is the *cæcitas senilis*. Sounds at first confusedly affect the ear, and soon it becomes entirely insensible to them; the cutaneous surface shrivelled and hardened and deprived of its vessels which are partly obliterated, is the seat only of an obscure and indistinct touch. And moreover the habit of feeling has blunted its sense of feeling. All the organs depending on the skin are enfeebled and destroyed; the hair and beard grow white. Deprived of the juices which nourished them a great number of the hairs falls off. Odours make but a feeble impression on the nose.

The taste is in some measure kept up, because, connected as much to organic as to animal life, this sense is necessary to the internal functions: thus when all agreeable sensations are fled from the aged man, when their absence has already in part broken those relations which attached him to surrounding bodies, this still remains to him: it is the last thread by which is suspended the happiness of existing.

Thus isolated* in the midst of nature, already partly deprived of the functions of the sensitive organs, the old man is soon destined to experience the extinction of those of the brain also. Perception no longer exists, inasmuch as there remains nothing on the part of the senses, to produce its exercise; imagination grows dull and is soon altogether lost.

The memory of things present is destroyed, the old man forgets in an instant what is just told to him, because his external senses enfeebled and already dead, as it were, do not confirm what his mind teaches him. Ideas fail, when

* Vide Walker's Dictionary.

the images traced by the senses do not retain their figure. On the contrary, the remembrance of the past still remains in this last age. What the old man knows of other times, his senses have taught, or at least confirmed to him.

He differs from the infant in this, that the latter judges only from the sensations he experiences, and the former from those he has experienced.

The result in these two states is the same, for the judgment is equally uncertain, whether exclusively called forth by present or past sensations; its correctness depends entirely upon their comparison. Who does not know, for example, that in judgments founded on vision, the actual impression would often deceive us, if the error was not rectifiedby the past? On the other hand, is it not often observed, that antecedent sensations soon become confused, if the features of the picture they have left in us are not retraced by new and similar sensations.

The present and the past therefore are equally necessary in our sensations, for the perfection of the judgment which is to result from them. Let one or the other fail; let there be no more comparisons between them, and there will be consequently no longer any precision in the judgment.

Hence it is that the first and last ages are equally remarkable for their incertitude, that we express ourselves correctly when we say that old men return to a second infancy; these two periods of life are allied by the irregularity of the judgment; they differ only in the principle of this irregularity.

As the interruption of the functions of the brain is in the old man a consequence of the almost entire destruction of those of the external sensitive system, so the enervation of locomotion and voice inevitably succeed to the inaction of

the brain. This organ in fact reacts upon the muscles in the same proportion as the senses act upon it.

The movements of the old man are slow and rare; he changes his attitudes with difficulty. Seated near the fire which warms him, he there passes his days involved within himself; a stranger to what surrounds him, deprived of all desire, sensation, or passions, speaking but little, inasmuch as he is excited by nothing to break silence, and happy in feeling that he still exists, when all other feelings have already nearly vanished.

I will add to this cause of inaction in old men, the rigidity and diminution of contractibility in the muscles; this doubtless has particular influence, but it is not the principal reason; for the heart and muscular fibres of the intestines acquire this rigidity also, and are notwithstanding not so soon deprived of the faculty of moving, as the voluntary muscles. It is not the faculty of moving which the latter lose, it is the cause which creates its exercise, I mean the cerebral action.

If it were possible to compose a man, partly with the organs of the senses and the brain of an old man, and partly with the muscles of a youth, the voluntary motions of such a man would be scarcely more developed, because it does not suffice that a muscle *can* contract itself, it is necessary its *power* of doing so should be put in action; now what cause is there to produce the action in this instance?

It is easy to see, from what we have just said, that the external functions are destroyed gradually in the old man, that animal life has almost entirely ceased, while the organic is still in activity. In this respect, the state of the animal about to die a natural death, is similar to that of the fœtus in the womb, and to the vegetable also, which lives only within itself, and for which all nature is a blank.

If we recollect now that sleep occupies more than one third of the duration of animal life; if we add this intermission of action to its complete absence in the first nine months, and to the almost entire inactivity to which it is reduced in the last stages of existence, it will be easy to see how vast is the disproportion of its duration with that of organic life, which is exercised in one uninterrupted manner.

But why, after we have ceased to live *externally*, do we still exist within, since the senses or locomotion, &c. are particularly destined to place us in a relation with those bodies which are to support us? Why are these functions enervated in a proportion so much greater than the internal ones? and why is there not an exact conformity in their times of cessation?

I cannot entirely resolve these questions, but will observe that society has a particular influence on this difference.

Man in midst of his fellow mortals, makes great use of his animal life, the springs of which are constantly more fatigued than those of organic life. All is worn out in this life under social influence; the sight by artificial lights; the hearing by sounds too often repeated, particularly by speech which is wanting in animals whose communications between themselves, by means of the ear, are much less numerous; the smell by corrupt odours; the taste by savours which are not to be found in nature; the *touching* and the *touch* by the use of garments; the brain by reflection, &c. and the whole nervous system by a thousand different affections which are brought on, or at least greatly multiplied by society alone.

We live therefore externally to excess, if I may use this term; we abuse the animal life; it is circumscribed

by nature within limits which we enlarge too much for its duration. It is not astonishing then that it should so speedily end. We have seen that the vital powers are divided into two orders, the one belonging to this, and the other to organic life. These two orders may be compared to two lights burning at the same time, and which have only a certain quantity of matter to feed them. If the one is more excited than the other, or more agitated by the wind, it must necessarily be the soonest extinguished.

This influence of society upon the two lives, is to a certain degree advantageous to man, inasmuch as it disengages him by degrees from the ties which bind him to what surrounds him, and thus renders the moment less cruel which is to destroy these ties.

The idea of our last hour is painful only because it terminates our animal life, because it produces the cessation of all those functions which placed us in connexion with surrounding beings. It is the privation of these functions which spreads terror and dismay on the borders of our grave.

It is not the pain which we dread: how many dying creatures are there who ardently wish to live, though death would bring them relief from a series of uninterrupted sufferings. Observe the animal who lives but little externally, and who has no correspondence except for his material wants, he does not tremble at the approach of death.

If it were possible to suppose a man whose death, bearing reference only to all the internal functions, as circulation, digestion, the secretions, &c., should leave in existence the whole animal life, this man would look upon the approaching end of his organic life with an indifferent eye,

because he would feel that the happiness of existence was not attached to it, and that he would still be in a state after this sort of death, of feeling and experiencing almost all that before constituted his happiness.

If animal life therefore ceases by gradations; if each of the links which chain us to the pleasure of living, is broken by degrees, this pleasure will escape us without our perceiving it, and the man will have already forgotten its value when death shall overtake him.

This is what we observe in the old man who comes, by the successive and partial loss of his external functions, to the total loss of his existence. His destruction approaches that of the vegetable, which, for want of external relations, having no consciousness of its life, can have none of its death.

SECTION II.

Organic life does not end in natural, as in accidental death.

Organic life which is left to the old man, after the almost total loss of his animal life, terminates in a manner entirely different from that of its end in violent and sudden deaths. The latter have truly two periods: the first is marked by the sudden cessation of respiration and circulation, a double function which in these cases almost always ceases at the same time with animal life; the second, more slow in its phenomena, shows us the term of the other organic functions, brought on in a gradual manner.

The digestive juices still dissolve the food that is found in the stomach, and upon which its coats, long enough

irritable, can also act. The experiments of the English and Italian physicians upon absorption, all of which have been repeated by me, prove that this function often remains in activity after general death, if not so long as has been asserted by some, at least for a very considerable interval. It is well known to every body, that the excretions of urine and fœcal matter, the effect of the remaining irritability in the bladder and rectum, are carried on many hours after sudden deaths.

Nutrition is still manifest in the hair and nails; it would no doubt be so also in all the other functions, as well as the secretions, if we could observe the insensible motions from which they result. After the heart is taken out of frogs, it may still be observed that the capillary circulation is carried on under the sole influence of the tonic powers. Animal heat is retained in most sudden deaths, particularly in asphixia, much longer than the term necessary for dead bodies to lose that which ceases to be given out, at the instant that general life ceases.

I could add to these observations a number of other facts to establish the position that organic life finishes, in sudden deaths, in a slow and gradual manner; that these deaths destroy in the first place the harmony of the internal functions, that they also strike with the same blow general circulation and respiration, but they bear only a *successive* influence on the other functions.

On the contrary, in that which is brought on by old age, the *whole* of the functions cease only because each is successively extinguished. The powers abandon each organ by degrees; digestion languishes; the secretions and absorption come to an end; capillary circulation is embarrassed: deprived of the elastic powers which habitually belong to it, it stops. At last death creeps in upon the

general circulation in the great vessels also. The heart is the last to finish its contractions: it is, as has been said, the *ultimum moriens*.

Here then is the great difference which distinguishes death by old age, from that which is the effect of a sudden blow; in the former, life begins to be extinguished first in all the parts, and ceases at last in the heart: death extends its empire from the circumference to the centre. In the latter, life is extinguished first in the heart, and then in all the parts: in this case it is from the centre towards the circumference that death displays it phenomena.

END OF THE FIRST PART.

RESEARCHES, &c.

PART II.

ARTICLE I.

GENERAL OBSERVATIONS UPON DEATH.

IN the first part of this work, I have explained, the two great divisions of general life; the remarkable differences which distinguish the animal living *externally* with relation to what surrounds him, from the animal existing solely within itself; the characters exclusively belonging to each of the two secondary lives, animal and organic; and the particular laws according to which both commence, are developed and extinguished in the natural order.

I shall endeavour in this second part, to find out how they finish accidentally, and how death arrests their course before the term fixed by nature for their duration.

Such indeed is the influence exercised upon them by society that we rarely arrive at this term. Almost all other animals attain it, while the cessation of our being, brought on by old age only, is become a sort of phenomenon. Accidental death therefore deserves our most particular attention. But this happens in two different man-

ners: sometimes it is the sudden result of great commotion excited in the animal economy; and sometimes diseases bring it on in a slow and gradual manner.

It is, in general, easy enough to discover according to what laws the functions are terminated, in consequence of a sudden and violent blow, as, for example, in apoplexy, excessive hemorrhages, asphixia, &c. because all the organs being then perfectly untouched, cease to act from causes directly opposite to those which keep them ordinarily in exercise. Now, as the latter are partly exposed to view, their knowledge leads us to that of the others, almost necessarily; and moreover we may imitate this kind of death upon animals, and consequently analyze by experiment its new phenomena.

It is, on the contrary, seldom in our power to produce in the species different from our own, artificial diseases similar to those which afflict us. And science would gain but little, by such a process: for the vital laws are so modified, changed, and I might almost say, deprived of their nature by morbid affections, that we can no longer depart from the known phenomena of the living animal to seek for those of the animal in death. In order to this, it would be necessary to know what is that intermediate state between health and death, in which all the functions experience so remarkable a change, a change, which, infinitely varied, produces such innumerable varieties of disease. What physician is there who can, according to the actual data of his art, pierce the thick veil which here hides from his view the operations of nature? What judgment is there that would dare on this head to go beyond the limits of strict observation?

We shall have more regard to the first than to the second kind of death in these researches. The latter will occupy us only secondarily: to understand well its causes, would

require a medical experience much above my age, and which can be given only by the habit of seeing many patients.

The first remark produced by an observation of the different kinds of sudden deaths, is, that in all, organic life may to a certain point exist, after animal life is extinct; that the latter on the contrary is in such dependance on the former, that it never endures after its interruption. The individual struck by apoplexy, &c. lives for many hours within, whereas he ceases to exist all at once from without: death commences in this instance, in animal life. If, on the contrary, it exercises its first influence on any of the essential organic functions, as upon the circulation in wounds and aneurismal ruptures of the heart, &c. or upon respiration in asphixia, &c. then these functions finish suddenly, it is true, but animal life also is equally destroyed all at once; and in this case also a part of organic life exists, as we have seen, a longer or shorter time, to be extinguished only by gradation.

You will never find a warm and red blooded animal to live externally, after it has ceased to exist within: so that the cessation of organic phenomena is always a certain indication of general death. We can never indeed pronounce upon its reality until after this has taken place, the interruption of external phenomena being almost always an illusory sign.

Upon what does this difference, in the manner in which the two lives terminate accidentally, depend? it proceeds from the mode of influence which they exercise upon each other, and upon the sort of connexion which unites them; for though they are distinguished by numerous characteristic marks, their principal functions are notwithstanding reciprocally connected.

This mode of influence and this bond of the two lives appear particularly to exist between the brain, on the part

of animal life, and the lungs or heart on the part of organic life. The action of one of these three organs is essentially necessary to that of the other two. When the one ceases entirely to act, the others cannot continue in activity; and as they are the three centres from which all the secondary phenomena of the two lives take their rise, these phenomena must inevitably be interrupted also, and general death ensue.

Physiologists of all times have acknowledged the importance of this triple focus: those functions which have their seat in them are pretty generally called vital functions, because life is immediately dependant on them, whereas it has only more distant connexions with what are called natural and animal functions.

I trust that after what has been heretofore said, the division which I have adopted will be found preferable to this; but it does not deserve to occupy our attention the less under the point of view in which I am now considering it.

Every kind of sudden death commences, in fact, by the interruption of circulation and respiration or of the action of the brain.

The one of these three functions ceases at the first. The others then in succession; so that, to explain correctly the phenomena of these kinds of deaths, we must consider them under these three particular respects: and this is the order which we shall follow.

Sudden deaths which have their principle in the heart, will occupy us in the first place; and in the next place our attention will be directed to those which begin by the lungs and the brain. In each I shall first explain how the two remaining organs die, by the affection of the one; I shall demonstrate by what mechanism the death of all the parts

results from that of the affected organ. In fine, I shall determine, after the principles I shall have made known, the nature of the different species of maladies which affect the heart, lungs or the brain.

ARTICLE II.

OF THE INFLUENCE WHICH THE DEATH OF THE HEART EXERCISES UPON THAT OF THE BRAIN.

I SHALL have manifestly determined what is this mode of influence, if I establish in what manner the action of the heart supports that of the brain; for here the cause of death is nothing more than the absence of that of life: the latter being found out, the other will be known of course. Now the heart cannot act upon the brain, but in two ways; namely, by the nerves, or by the vessels which serve to unite them. These two organs have indeed no other means of communication.

It is evident that the nerves are not the agents of the connexion which at present occupies us: for the brain acts through their medium, upon the different parts, whereas the different parts never influence the brain by their means, unless it be in sympathies. Tie a nervous fascia in its course to the voluntary muscles: these muscles cease their functions, and no part of the cerebral mass is altered.

I am persuaded, from various experiments, that the galvanic phenomena which extend themselves so energetically

from the brain towards the organs where the nerves are distributed, and which *descend* along the course of the nerve, if I may thus express myself, almost never ascend in an opposite direction. Bind a lumbar nerve and the muscles of the superior limbs; and then make a communication between the two ligatures: there will be no contractions, or at least they will be scarcely sensible; while if, the ligature on the nerve still remaining, the other is carried under the muscles of the inferior limbs, so that a communication be established, violent convulsive motions will take place immediately. I have also observed that by placing two metallic plates, one under the lumbar nerves, and the other under the superior limbs, the communication of these two plates by means of a third metal, produces the action of the inferior limbs, then freed from their ligatures while the superior limbs either remain motionless, or have a very feeble motion.

These experiments are particularly applicable to the heart with respect to the brain. The division, ligature, or compression of the cardiac nerves, not only have no effect on the functions of the second; but they affect only indirectly the motions of the first, as we shall see.

We may therefore venture to assert that the vessels are the exclusive agents of the heart's influence on the life of the brain.

The vessels are known to be of two sorts, arterial or venous, or those carrying red or black blood. The first go from the left and the second to the right side of the heart. But their functions being very different, the action of one of the portions of this organ on the brain, cannot be the same with that of the other portion. We shall endeavour to find out how both act.

In mentioning these two portions, I shall not make use of the expressions *right* and *left* to distinguish them, but

of those of the *heart with red blood*, and *the heart with black blood*. Each one, in fact, forms a separate organ, distinct from that against which it is placed, and capable of not being joined to it in the adult. There are in reality two hearts, the one arterial the other venous. These adjectives however, do not well suit to distinguish them; for both form a system both with the veins and arteries; the first with the veins of the whole body and with the artery of the lungs, the second with the veins of this organ and with the great arterial trunc whose branches are distributed to every part of the body. Moreover, neither the one nor the other is exactly on the left or right, before or behind. And besides this denomination is not applicable to animals. That *with red* and *with black blood* being borrowed from the two systems of blood of which each is the centre and agent of impulsion, appears to me infinitely preferable.

SECTION I.

Explanation how the cessation of the functions of the HEART WITH RED BLOOD, *interrupts those of the brain.*

The ventricle and auricle with red blood manifestly influence the brain by the fluid which the carotid and vertebral arteries carry to it. Now this fluid, upon its arrival there, may excite it in two ways; 1st, by the motion with which it is agitated; and 2ndly by the nature of the principles which constitute it, and which distinguish it from the black blood.

It is easy to prove that the motion of the blood, in communicating itself to the brain, keeps up its action and its

life. Expose this organ partly to view in an animal, so as to see its motions; and then place a ligature in the carotids. Sometimes the cerebral motion is weakened, and then the animal is stunned; at other times it continues as usual, the vertebrals exactly supplying the deficiency of the tied arteries, and then none of the principal functions are disordered. There is always a correspondence between the vital energy, and the alternate depression and elevation of the brain.

In general, the obliteration of the carotids is never suddenly mortal. Animals can live without them, at least for a certain time. I have kept in this state, for several days, dogs which have afterwards served me for other experiments: two, however, survived only six hours.

If, after the experiments of which I have just spoken, a portion of the cranium is taken away in another animal, and the course of the blood, in all the vessels which go to the head, is intercepted, the encephalic motion will be seen to cease immediately, and life destroyed.

The general shock or agitation, produced by the entrance of the blood to the brain, is therefore a condition essential to its functions. But let us rest this assertion upon further proofs.

1. There are numerous means of compression which can evidently act only by preventing the organ from obeying these shocks. Purulent or bloody collections, the splinter of a bone, &c. are often found to interrupt all the functions relative to perception, imagination, memory and voluntary motion also. Let these different causes of compression be removed, and instantly all the sensations are renewed. It is clear, therefore, that in this instance the brain was not disorganized, that it was only weighed down, and beyond the state of being excited by the heart.

I shall offer no observations upon these cases. All the authors who have treated of wounds of the head furnish them in abundance. I shall content myself with remarking that we may artificially produce the same effect in experiments upon animals. Alternately compressed and free, the brain is successively in a state of excitement or collapse, according as the blood raises and agitates it with more or less facility.

2. There are some species among reptiles, in which the heart causes no motion in the cerebral mass. I have often made this observation in the frog. Upon removing the superior portion of the cranium, and exposing the brain exactly to view, not the slightest heaving is perceptible. In this species, as well as in salamanders, we may deprive this organ of all approach of the blood, without producing the immediate cessation of the functions, as happens in all the species with red and warm blood.

The voluntary muscles act; the eyes are lively; the touch is manifest for some time, after the heart has been taken out, or a ligature placed on the double branch arising from the great vessel furnished by the only ventricle of the heart of these animals. I have repeated these two methods of interrupting the general circulation, a great number of times, and the same effect has invariably resulted, as it respects the brain.

3. It is generally observed, as some physician has remarked, that animals with long necks, in which the heart, of course more distant from the brain, can less violently agitate this organ, have a more limited intelligence, and the cerebral functions consequently more contracted; and that on the contrary a very short neck and the near vicinity of the heart to the brain, commonly coincide with the energy of the latter. Men whose heads are very far

from the shoulders, compared to those in whom the distance is short, sometimes offer a verification of the same remark.

After all these facts, we may, without fear of error, establish the following proposition; namely, that one of the means by which the heart with red blood holds in dependence the phenomena of the brain, consists in the habitual motion which it impresses on this organ.

This motion differs essentially from that which, in the other viscera, as the liver, spleen, &c. arises from the same cause: the latter indeed discover it in a manner less manifest; in the brain, on the contrary, it is very apparent. This arises from the following cause, that all the great arterial truncs placed at the base of the brain, being situated there between it and the bony walls of the cranium, experience, at the instant they grow straight, a resistance which creates a repercussion of the whole motion upon the encephalic mass: the latter is raised by this straightening, as happens in the different species of tumours, when a considerable artery passes between them and a very solid plain.

Tumours situated in the neck, on the carotid, at the place where it rests upon the vetebral column, and in the groin, on the crural where it traverses the bony arches of the same trunc, &c. frequently afford us similar examples, and thereby, motives to examine carefully if it is not an aneurism.

No organs, besides the brain, have their bases resting upon resisting surfaces, like that of the inferior part of the cranium. The motion of the arteries too, which go to them, losing themselves in the cellular texture and surrounding soft parts, have scarcely any effect upon these organs, as may be observed in the liver, kidney, &c. and

as may be seen also in tumours of the mesentery, and in all those seated upon arteries, having underneath only muscles or organs with a soft and spungy texture.

The integrity of the functions of the brain is not only dependant on the motion communicated to it by the blood, but likewise on the *sum* of this motion, which should be always in a just medium: too feeble or too impetuous, it is equally hurtful; the following experiments will prove this.

1. Inject water into the carotid of a dog; the contact of this fluid is not fatal, and the dog will live very well, if the injection has been made with care. But force it impetuously; the cerebral action is immediately disturbed, and is often restored only with difficulty. There always exists a connexion between the force of the impulsion, and the state of the brain; if this impulsion is but slightly augmented, there is a sudden agitation in the muscles of the face, eyes, &c. Composure is restored, if the impulsion is diminished; death supervenes, if it is carried to the highest degree.

2. On the other hand, if you expose the brain to view, and then open an artery so as to produce hemorrhagy, you will observe the motion of the brain to diminish in proportion to the loss of blood, and at length discontinue when there is no longer a sufficient quantity of this fluid to communicate it. Now the cerebral energy, which in this instance may be marked by the state of the eyes, the touch, the voluntary motions, &c. is always found to grow weak, and to cease proportionally.

It is easy to see, after this, why a diminution of the encephalic motion always accompanies that state of prostration and languor, &c. the constant effect of large evacuations of blood.

It will be very easily conceived also, I trust, from what has been said above, why the whole arterial system of the brain is at first concentrated at its base, before it is distributed among its lobes; while the great venous truncs are observed almost exclusively on its convex superficies. This organ presenting less surface below, is more susceptible there of receiving the influence of the vascular motion, than upon its convexity where this motion would have been too much disseminated to have produced upon it so decided an effect. Besides all the essential parts of the brain are situated below. Injuries there are mortal, and consequently its functions must be very important in this place. Above, on the contrary, cutting or lacerating it, does not often disturb its action much, as is proved by experiments and frequent observation in wounds of the head.

Hence it is that this organ on one side presents an envelop almost impenetrable to external agents, and that on the other side the arch which protects it, does not oppose so solid an obstacle. Now it was indispensable that where life is most active, or its energy most necessary, it should there receive from the heart the first and strongest shock.

We are, I think, right in concluding, after all that has been said in this paragraph, that the interruption of the action of the heart with red blood causes a cessation of that of the brain, by destroying its motion.

This motion is not the only mode of influence of the first upon the second of these organs; for if this was the case, by injecting an aqueous fluid into the carotids by means of a bifurcated pipe, and with an impulsion equal to that which is natural to the blood, one might agitate the organ, and thus reanimate its enfeebled functions. Pushed forward with an equal force, the black and red

blood would not have a different action upon it; which, as we shall see, is manifestly contrary to experiment.

The ventricle and auricle with red blood therefore, act also on the brain, by the nature of the fluid which they send to it. But as the lungs are the focus in which the blood is prepared which traverses the heart without undergoing any alterations there, we shall refer the examination of its influence upon the cephalic system, to the article in which we shall treat of the connexions of this system with the pulmonary.

SECTION II.

Inquiry how the cessation of the functions of the heart with black blood interrupts those of the brain.

It is extremely rare that general death commences by the ventricle and auricle *with black blood;* they are on the contrary almost always the last in action. When they cease to act, the brain, the *heart with red blood*, and the lungs have already lost their functions.

A wound, nevertheless, or an aneurismal rupture, may all at once destroy their contractions, or at least render them useless to the circulation, by reason of the flow of blood out of the passages of this function.

The brain then becomes inactive and dies after the same manner as in the preceding case; for the cavities of red blood, ceasing to receive this blood, cannot throw it on towards the head: there can consequently be no longer any motion, and soon for the same reason no more life in the encephalic mass.

When the ventricle and auricle *with black blood* cannot receive this fluid, it produces another kind of death in the

brain: this is the case when all the jugulars being tied, it necessarily stagnates or ascends into the cerebral venous system. This system is then choked up; the brain is clogged; it ceases to act, compressed both by the reflux of the black blood and the influx of the red, into its substance. But authors enough have made these experiments, and given their results; it is therefore unnecessary to say more upon them.

I shall examine in this article a kind of death the principle of which is placed by most authors in the heart, particularly in the side with black blood, but which appears to me to depend principally if not entirely on the brain. I speak of that death which is produced by the injection of air into the veins.

It has been generally and for a long time known, that when any quantity of this fluid is introduced into the vascular system, the motion of the heart is quickened; the animal is agitated, gives a cry of pain, is seized with convulsive motions, falls deprived of animal life, still lives organically for sometime, and soon ceases entirely to exist. What organ is so readily affected by the contact of the air? I say that it is the brain and not the heart, that the circulation is interrupted only because the cerebral action is first destroyed. The following are the proofs of this assertion:

1. The heart still beats for sometime in this kind of death, after the animal life, and consequently the brain which is its centre, have ceased to be in activity.

2. By throwing air into the brain by one of the carotids, I have produced death with similar phenomena, except the agitation of the heart, an agitation produced by the contact of a foreign body against its walls, which for that reason powerfully excites it.

3. Morgagni relates several instances of sudden deaths whose cause appeared to be evidently the repletion of the sanguinary vessels of the brain, by air spontaneously emitted from them, and which, as he says, had compressed the origin of the nerves by its rarefaction. I do not believe that this compression could be the result of the small quantity of air which, being pushed on by the carotid, suffices to kill the animal. I doubt also, whether this compression, as observed by Morgagni, really existed; but his observations are not the less important. Whatever may be the mode by which it destroys life, the air is certainly mortal upon getting to the brain, and that is the essential point. The manner is unimportant to our considerations, the fact alone interests us.

4. Whenever an animal perishes by the injection of air into one of its veins, I am persuaded that the whole side of the heart *with red blood*, like that with *black blood*, is full of a frothy blood, mixed with bubbles of air; that the carotids and vessels of the brain contain it also, and that consequently it must act upon this organ after the same manner as in the two species of artificial and spontaneous apoplexy, of which we have just spoken.

5. If air is thrown into one of the divisions of the vena porta, on the side of the liver, it can with difficulty pass into the capillary system of this organ; it has an oscillatory motion in the great truncs, goes very slowly to the heart, and I have remarked that the animal does not then experience, until after a long time, those symptoms which are sudden when the fluid is made to penetrate one of the veins of the great system, because in the latter case the heart transmits it immediately to the brain.

6. This rapidity with which, in certain experiments, the destruction of the cerebral action succeeds to the inflation of air into the veins, might induce a belief, with a number

of authors, that this phenomenon happens in the same manner that is manifested in wounds of the heart, syncope, &c. that is to say, because the action of this organ all at once suspended by the prescnce of the air which distends its walls, can no longer communicate motion to the brain. But, in the first place, the slightest inspection is sufficient to observe the permanence of the heart's motion; and in the second place, as its motions are prodigiously accelerated by the contact of the foreign fluid, they push on the frothy blood through the lungs and arterial system with extreme rapidity, and hence this rapidity may be conceived in injuries of the brain.

7. If the brain ceased to act from the absence of the motions of the heart, death would supervene, as in syncope, in great hemorrhagies from the aorta, ventricles, &c. that is to say, without violent convulsive motions. Here, on the contrary, these motions are often extremely violent an instant after the injection, and therefore announce the presence of an irritating cause in the brain: now this irritating cause, is the air abounding in it.

We may conclude from all that has been said, that in the accidental mixture of air with the blood of the venous system, it is the brain that dies first, and that the death of the heart is the result, the effect and not the principle of this. I shall elsewhere explain how the action of the second organ is interrupted, by its cessation in the first.

ARTICLE III.

OF THE INFLUENCE OF THE DEATH OF THE HEART UPON THE LUNGS.

THE lungs are the seat of two very different species of phenomena. The first, which are entirely mechanical, relate to the motions of elevation or depression of the sides of the diaphragm, to the dilatation or collapsion of the air vesicles, and to the entrance or egress of the air, the effect of these motions. The second, purely chymical, relate to the different alterations which the air experiences, and to the changes in the composition of the blood, &c.

These two species of phenomena are in a state of mutual dependance. The moment the one is interrupted the others also cease to be developed. Without the chymical operations, the mechanical, failing in materials, could not be exercised. In defect of these last, the blood ceasing, as we shall see, to prove an excitement to the brain, the latter could not extend its influence to the intercostal muscles and diaphragm; these muscles would become inactive, and thence the mechanical phenomena would be annihilated.

The death of the heart does not terminate these two species of phenomena in the same manner. According as it results from an injury of the side with black blood, or of the great venous truncs, from an affection of the side with red blood, or of the great arteries, it affects the lungs differently.

SECTION I.

Investigation of the manner in which the cessation of action in the heart with black blood, *interrupts the action of the lungs.*

The heart with black blood has no visible influence on the mechanical phenomena of the lungs; but it concurs essentially to produce the chymical, by sending to this organ that fluid which is to imbibe new principles from the air, and to communicate to it those with which it is surcharged.

When therefore the ventricle and auricle of the system with black blood, or some of the great venous vessels which concur to form this system, are interrupted in their functions, as happens by wounds, by ligatures made in experiments, &c. then the chymical phenomena are at once annihilated; but the air still enters into the lungs by the dilatation and compression of the breast.

Notwithstanding nothing happens to the ventricle with red blood: if a small portion of blood enters it for some instants, it is black, having undergone no alteration. Its quantity is insufficient to produce the cerebral motion, which ceases for want of an agent of impulsion. The functions of the brain are thence suspended, as has been said above: consequently no farther action can take place on the intercostals or diaphragm, which remain at rest, and leave the mechanical phenomena without exercise.

Here then is an explanation how the death of the lungs happen, when the heart with black blood loses its life. It succeeds in an inverse manner to the death of the heart with red blood.

SECTION II.

How the action of the lungs is interrupted, by the cessation of action in the heart with red blood.

When a wound is given to the ventricle or auricle with red blood, to the aorta or its great divisions; when a ligature is applied artificially to the latter, or when an aneurism bursts in them, &c. the lungs cease their functions in the following order:

1. There is no more impulsion received by the brain; 2d, no longer motion of this organ; 3d, no more action exercised on the muscles; 4th, no more contraction of the intercostals and diaphragm; and 5thly, there are no more mechanical phenomena. Without the latter, the chymical cannot take place; they are interrupted in the preceding case, for want of blood: in the present case it is the want of air which stops them; for these two things are equally necessary; without the one the other is of no use.

Such then is the difference of death in the lungs after injuries done to the heart, that if it is the side with black blood which is affected, the chymical phenomena cease first, and then the mechanical; and vice versa, if the affection is in the side with red blood. As the circulation is very rapid, a very short interval divides their annihilation.

ARTICLE IV.

OF THE INFLUENCE THAT THE DEATH OF THE HEART HAS UPON ALL THE ORGANS.

I SHALL divide this article, like the preceding, into two sections; the one shall be devoted to inquire how all the organs are interrupted, when the heart with red blood ceases to act; and in the other I shall investigate the influence of the heart with black blood, upon all the parts.

SECTION I.

Examination how the cessation of the functions of the heart with red blood interrupts those of all the organs.

ALL the functions belong either to animal, or organic life. Thence they are divided into two very distinct classes. How is the first class interrupted in injuries of the auricle or ventricle with red blood? This happens in two ways: first, because the brain, rendered motionless, becomes inert, and can neither receive sensations, nor exert its influence on the locomotive and vocal organs.

All this order of functions then are stopped as when the encephalic mass has experienced such violent commotion as suddenly to destroy its action. Hence a wound in the heart, or the bursting of an aneurism, &c. at once annihilate our connexions with external objects.

This connexion between the motion of the heart and the functions of animal life is not observed in animals, in which the brain does not stand in need of an habitual shock from the blood to give it action. Take out the heart of a reptile, or tie its large vessels, it will notwithstanding live for a long time as to what surrounds it ; locomotion, sensations, &c. will not be extinguished on the instant, as in the red and warm-blooded species.

Besides, supposing that the action of the brain was not interrupted by injuries of the heart with red blood, animal life would still be destroyed, after a longer interval, it is true, but not the less certain; for, to the exercise of the functions of this life is attached, as a necessary cause, the excitement of its organs by the entrance of the blood: now this excitement depends here, as elsewhere, upon two causes: 1st, to the motion, and 2d, to the nature of the blood. Here I shall examine only the first mode of influence; the other belongs to the lungs.

It is not only in animal, but in organic life also, that the parts require an habitual motion to keep up their action: this is an essential condition to the functions of the muscles, glands, membranes, vessels, &c. But this motion, arising partly from the heart, differs essentially from that which the blood communicates to the brain.

This last organ, in a very sensible and apparent manner obeys the impulsion which raises its whole pulpy mass, or suffers it to sink during the intermission. The internal motion, on the contrary, which agitates each of its parts individually, is but slightly perceptible: this arises from its vessels, infinitely divided, first in its sinuosities, and then over the pia mater, penetrating its substance only by almost imperceptibly minute ramifications.

The motion produced in the other organs by the entrance of the blood, affords a phenomenon diametrically opposite: neither elevation nor depression is to be observed in them; they are not agitated by a general shock, because, as I have said, the impulsion of the arteries is lost in the surrounding soft parts, while the hard unyielding parts in the neighbourhood of the brain, occasion a repercussion upon this organ. On the contrary, the vessels entering into almost all the organs by large truncs, which have been previously but little divided, their pulsation produces in them an intestine motion, partial oscillations, and appropriate shocks to each of the lobes, fibers, &c. of which they are made up.

Compare the manner in which the brain on the one hand, and the liver, spleen, kidneys, muscles, skin, &c., on the other hand, receive the blood which supports them, and you will easily conceive this difference.

It was necessary the brain should be distinguished from the other organs by the motion impressed on it by the entrance of the blood, because, enclosed in a bony case, it is not like them, exposed to a thousand other causes of general agitation.

It may be remarked, in fact, that all the organs are surrounded by agents intended to make up to them for that impulsion denied to them by the heart. In the thorax, the alternate elevation, and depression of the intercostal muscles and diaphragm, the successive dilatation and contraction of the lungs and heart, in the abdomen, the uninterrupted agitation produced in the abdominal pariates by respiration, the incessantly varying state of the stomach and intestines, and of the bladder, being alternately distended or contracted; the continual changes of situation in the floating viscera, occasioned by the various attitudes

we take; in the limbs, their flexion and extension, the action of the adductor and abductor muscles, &c. which take place at every instant, for various purposes; these are the permanent causes of motion to keep up the life of those organs, and are certainly equivalent to those resulting from the entrance of the blood to the brain.

I do not mean, however, to exclude altogether this last cause of excitement necessary to the life of the organs; it acts probably in conjunction with that which I have just mentioned; and hence it is, no doubt, that most of the viscera, as well as the brain, receive the red blood by this concave surface, as is observed in the kidneys, liver, spleen, &c. By this disposition, the impulsion of the heart being less disseminated, is more easily felt; but this is only an accessory condition to the support of the functions.

After all that has been just advanced, we may add one reason to that given above, to establish, how the interruption of all the functions of animal life takes place, upon the cessation of action in the heart with red blood. We may also begin to explain the same phenomenon in organic life: for the reason is common to both. Here it is:

1. The intestine motion, created in each of the organs of the two lives by the mode of arterial distribution, being then totally suspended, there is no more excitement in these organs, and soon for the same reason no longer any life; 2d, they have no longer causes of general agitation around them; for almost all these causes depend on motions governed by the brain: such are those of respiration, of the locomotion of the limbs, of the eye, of the subcutaneous muscles, &c. Now, as the brain is in a state of collapse—from the moment it ceases to receive any thing from the heart, all its motions are also manifestly

annihilated, and consequently the excitement proceeding from it to the neighbouring organs is destroyed.

It follows hence, that the heart exercises two modes of influence upon the different organs, the one direct and without interposition, the other indirect, and through the medium of the brain; so that the death of these organs, by injuries done to the former, happens mediately and immediately.

We have sometimes examples of partial deaths similar to this general death: as when the circulation in a limb is impeded in such a manner, that the red blood can be no longer distributed to its different parts, these parts are at first affected with insensibility and paralysis, and soon afterwards with gangrene.

Operations for aneurisms furnish us with but too many examples of this phenomenon, and experiments upon living animals equally produce it.

No doubt the defect of action, arising ordinarily from the elements which compose the red blood, and which distinguish it from the black, has a particular influence in these cases; but that proceeding from the absence of the intestine motion that the blood communicates to the parts, is no less real.

As to the interruption of nutrition, that cannot be admitted as the cause of the symptoms, which succeed to the obliteration of a large artery; the slow, gradual, and insensible manner, in which this function operates, does not visibly accord with their sudden and instantaneous invasion, particularly with respect to the functions of animal life, which are destroyed in the limb, the very instant the blood ceases to flow thither, as they are also when, by the division of the nerves, it is deprived of their influence.

Besides the preceding causes which, when the heart ceases to act, suspend all the animal and organic functions in general, there is another relation to the greater number of these functions, namely, nutrition, exhalation, secretion, and of necessity, digestion which operates only by the secreted fluids. The other cause consists in this, that the different functions no longer receiving the materials which support them, necessarily cease. Their end, however, comes on slowly, because it is not in the general, but in the capillary circulation, that they take up these materials; now this last circulation is subjected only to the influence of the insensible contractile powers of the part, in which it is exercised; it is carried on independent of the heart, as may be seen in most reptiles, where this organ may be taken out, and where, when it is wanting, the blood still oscillates for a long time in the small vessels. It is therefore manifest, that the whole portion of this fluid, which is found in the capillary system, at the instant in which the general circulation is interrupted, must still supply these functions for some time, and that they must consequently cease gradually.

These then are generally the means by which the annihilation of all the functions succeeds to the interruption of those of the heart.

In animal life, it is 1st, because all the organs cease to be excited from within by the blood, and from without by the motion of the neighbouring parts; 2dly, because the brain failing also of exciting causes, cannot communicate with any of these organs.

In organic life, the cause of the interruption of its phenomena is this: 1st, as in the animal, the defect of the internal and external excitement of the different viscera; 2dly, the absence of the materials necessary to the dif-

ferent functions of this life, all strangers to the influence of the brain.

Moreover, numerous considerations, besides those above mentioned, prove both the reality of the excitement of the organs, by the motion impressed on them by the heart, or vascular system, and the truth of the cause to which we ascribe their death, when this excitement ceases. Some of these considerations follow:

1. Those organs which receive no blood, and which are penetrated only by the white fluids, such as the hair, nails, beard, cartilages, tendons, &c. enjoy neither so distinct a degree of vitality, nor such energetic action, as those in which this fluid circulates whether by the influence of the heart, or by that of the insensible contractile powers of the part itself.

2. When inflammation produces an accidental determination of the blood to the white organs, these organs all at once acquire a surcharge of life, and a superabundance of sensibility which often place them, with respect to powers, on a level with those which in their ordinary state are endued with them in a much higher degree.

3. In parts that the blood habitually penetrates, if inflammation increases the quantity of this fluid, if an unnatural pulsation indicates an augmentation of impetuosity in its course, a local exaltation in the phenomena of the life is always to be observed. This change of powers precedes, it is true, that of the circulation, in the two preceding cases: because the organic sensibility has been augmented in the part, and the blood is at first carried to it in greater abundance; but it is afterwards the access of blood, which keeps up the power at that preternatural degree to which they are raised; it is the continual exciting cause of these powers. A determinate quantity of this

fluid was necessary in their ordinary state, to support them in the proportion fixed by nature. This proportion being then doubled, it is necessary the exciting cause should be also doubled, &c.; for there are always these three things in the exercise of the vital powers; the faculty, which is inherent in the organ; the exciting cause, which is foreign to it, and the excitement which results from their mutual contact.

4. It is doubtless for this reason, that in general, the organs to which the blood is habitually carried by the arteries, enjoy a degree of life in proportion to the quantity of this fluid, as is seen in the muscles, or still more in a gland, the corpus covenosum, &c. in the skin of the face in lively emotions, which give it a colour, and swell its texture, in the exaltation of the cerebral functions, when it is to them the blood is directed with impetuosity, &c.

5. After the same manner whatever increases any of the phenomena of the life individually, always produces a local increase of the circulation; and likewise, when the whole of those phenomena are exalted, the whole circulatory system has a more powerful action. The use of spirituous liquors, aromatics, &c. to a certain degree, is instantly followed by an augmentation of the energy, both in the powers and in the circulation: the paroxysms of an ardent fever double the intensity of the life, &c.

In these considerations, I have had regard only to the motion which the blood communicates to the organs; I make no mention of the excitement produced in them by the nature of this fluid, and by the contact of those principles which give it its colour. I shall hereafter call the attention of the reader to this subject.

These reflections will suffice to show, in what way the blood, by its simple entrance into the organs, and independantly of the nutritive matter, which it conveys to them, is necessary to the activity of their action, and how consequently the cessation of the functions of the heart, bears so immediate an influence upon their death.

ARTICLE V.

OF THE INFLUENCE THAT THE DEATH OF THE HEART EXERCISES UPON GENERAL DEATH.

WHENEVER the heart ceases to act, general death supervenes in the following manner: the cerebral action is destroyed in the first place, for want of excitement; hence the sensations, locomotion, and voice, which are under the immediate dependance of the encephalic organ, are interrupted. And besides, in defect of excitement on the part of the blood, the organs of these functions would cease to act, supposing the brain remained untouched, and still able to exert its ordinary influence on them. The whole animal life is therefore suddenly destroyed. Man ceases to exist with respect to what surrounds him, the instant the heart is dead.

The interruption of organic life, which has commenced in the circulation, is at work at the same time on the respiration. There are no more mechanical phenomena in the lungs, from the moment the brain has ceased to act, since

the diaphragm, and intercostal muscles depend on it. And there are no more chymical phenomena, when the heart can neither receive, nor send out the materials necessary to their development; so that in injuries done to the heart, these last phenomena are directly and immediately interrupted, and the first cease, on the contrary, indirectly and through the medium of the heart, which is the first to lose its existence.

General death then goes on in a slow and gradual manner, by the interruption of the secretions, exhalations, and nutrition. This last, is the first to cease in those organs, which are accustomed to receive the blood, because the excitement created by the entrance of this fluid, is necessary to maintain it in these organs; and it fails therefore by these means. It ceases only consecutively in the white parts, because, less under the influence of the heart, they do not so soon feel the effects of its death.

In this successive termination of the last phenomena of the internal life, its powers still exist for some time, after its functions have ceased: thus organic sensibility, and the sensible and insensible organic contractibilities, survive the phenomena of digestion, secretion, nutrition, &c.

Why do the vital powers still remain for some time in internal life, while those corresponding to them in the external life, namely, the species of sensibility and contractibility belonging to this life, are suddenly extinguished? It is because the action of feeling and moving organically, does not suppose the existence of one common centre, and on the contrary, the cerebral influence is necessary for animal motion and action. Now, the energy of the brain being extinguished as soon as the heart no longer acts, all external motion and feeling must cease at the same instant.

It is in the order I have just mentioned, that the phenomena of general death succeed each other, when produced by aneurismal ruptures, wounds in the heart or great vessels, polypi formed in their cavities, ligatures artificially applied, a too strong impression made upon them by tumours, and abscesses on their coats, &c.

In this manner also it is that we die in strong emotions of the mind. A man expires at the news of an event which transports him with joy, or throws him into despondency, at the sight of an object which inspires dread, of an enemy whose presence agitates him with fury, of a rival whose success excites his jealousy, &c.; in all these cases it is the heart which first ceases to act; it is the death of this which successively brings on that of the other organs; the passion has exerted its influence especially on it; hence its motion is stopped; and soon all the parts become motionless.

This brings us to the consideration of syncope, which presents the same phenomena with these species of sudden death, though in a less observable degree.

Cullen refers the causes of this affection to two general heads: the one existing, according to him, in the brain, the others in the heart. Among the first, he places, powerful emotions of the mind, various evacuations, &c. But it is easy to prove that the syncope which succeeds to these passions, only secondarily affects the brain, and that it is always the heart which, being first interrupted, produces by its temporary death the defect of action in the brain. The following considerations will leave, I think, but few doubts upon this head.

1. I have proved in the article on the passions, that they never exert their primitive influence on the brain; that this organ is only accessorily put in action by them; that whatever relates to our moral affections belongs to organic life, &c.

2. Syncopes produced by powerful emotions are altogether analogous in their phenomena, to those arising from polypi, dropsies of the pericardium, &c. In the latter, the first affection is in the heart; it must therefore be so in the others.

3. At the moment the syncope manifests itself, it is in the precordia, and not in the region of the brain, that we experience uneasiness. An actor who wishes to display this momentary death on the stage, always carries his hand to the heart and not to the head to express his agitation.

4. After lively emotions which produce syncope, many affections of the heart are often the consequence, but none of the brain: there is nothing more common than organic defects in this organ after trouble, &c. The various follies which are produced by the same cause, most frequently have their principal focus in some of the deeply affected epigastric viscera, and it is only by a counter blow that the brain ceases the regular exercise of its functions.

5. I shall prove hereafter that the cerebral system exercises no direct influence on the circulation; that there is no reciprocity between these two systems; that the alterations of the first do not bring on similar alterations in the second, while those of the second regulate the life of the first in a necessary manner. Destroy all the nervous communications which unite the heart with the brain, the circulation goes on as usual; but as soon as the vascular communications which hold the brain under the dominion of the heart, are intercepted, then there are no longer any apparent cerebral phenomena.

6. If the influence of the passions is not exerted to so high a degree as entirely to suspend the circulatory mo-

tion, and consequently to produce syncope, palpitations and other irregular motions frequently arise. Now it is constantly in the heart and never in the brain, that these secondary alterations have their seat, by which it is easy to distinguish the organ affected, because it alone is affected, and they do not all then cease to act, as happens in syncope. These slight affections of the passions on the heart, serve to show clearly the nature of the greater influences it receives from them in this affection.

We may conclude from these different considerations, that the primitive seat of the mischief in syncope, is always in the heart; that this organ does not then cease to act because the action of the brain is interrupted, but that the latter dies, because it does not receive from the former the fluid which habitually excites it, and that the vulgar expression of *sick at heart*, indicates correctly the nature of this disease.

Whether the syncope proceeds from a polypus, an aneurism, &c., or is the result of a strong emotion, the successive affection of the organs is always the same: they always die temporarily, as we have said they perish really in wounds of the heart, ligatures on the aorta, &c.

It is in the same manner also that those syncopes are produced which succeed to evacuations of blood, pus, water, &c. The heart, sympathetically affected, ceases to act, and immediately afterwards the action of the brain is interrupted, for want of an exciting cause.

Syncopes which are the effect of particular odours, antipathies, &c., appear also to run the same course in their phenomena, though it may be more difficult to come at their character,

There is a great difference between syncope, asphixia and apoplexy: in the first it is in the heart, in the second

in the lungs, and in the third in the brain, that general death commences.

Death which is the consequence of different diseases, usually develops its phenomena, first in one of these three organs, then in the two others, and lastly in the different parts. The circulation, respiration, or the cerebral action cease; the other functions are then interrupted necessarily. But it very rarely happens that the heart is the first to end in these sorts of death. It is nevertheless sometimes observed: thus, after long protracted pains, in large suppurations, in dropsies, in certain fevers, gangrenes, &c. syncope often supervenes at different intervals; to one of these fits, too violent for the patient to support, he is obliged to yield; and then whatever may be the part affected, the phenomena of death, beginning in the heart are concatenated in the same manner as we have explained them above in sudden deaths produced by wounds in this organ.

In the other cases, the heart ceases its functions after all the other parts; it is the *ultimum moriens*.

In general it is much more common in the different morbid affections, whether chronic or acute, for the breast to be embarrassed, and for death to commence in the lungs, than in the heart or brain.

When different diseases terminate in syncope, it is constantly found that the lungs of the corpse are in a state of almost complete vacuity; they are not engorged by the blood. If no organic defect existed in them originally, they are sunk, occupy only a part of the pectoral cavity, and retain their natural colour.

The reason of this anatomical fact is plain. The circulation which has been all at once interrupted, and not gradually enfeebled, has not had time to fill the vessels of the lungs, as is the case when general death begins in the

latter, and in the brain, as we shall see. I have opened a great number of bodies in which the lungs have been found thus empty, and in which I learned that life was terminated by syncope.

In general, whenever death has begun in the heart or large vessels, and has been sudden, we may consider the vacuity of the lungs as an almost universal phenomenon. It is remarked in large hemorrhagies from wounds, in aneurismal ruptures, in deaths produced by strong passions, &c. I have observed it in the bodies of persons executed by the *guillotine*. All the animals that are killed in our slaughter-houses present the same appearance. The lungs of veal which are served up at our tables are always compressed, and never imbued with blood.

We might, by causing the animal to perish slowly by the lungs, choke this organ with the blood, and give it a taste entirely different from its natural one, and something like what the spleen commonly possesses. Cooks have taken advantage of the bloody state in which these last viscera are almost always found, to season their different dishes. The same effect may always be produced in the lungs, by gradually suffocating the animal.

ARTICLE VI.

OF THE INFLUENCE THAT THE DEATH OF THE LUNGS EXERCISES ON THE HEART.

WE have said above that the functions of the lungs were of two sorts, mechanical and chymical. The cessation of activity in this organ, commences sometimes in the one, and sometimes in the other.

A wound of considerable extent, which exposes both sides, and produces a sudden sinking of the lungs; a division of the spinal marrow, which paralyses the intercostal muscles and diaphragm; a very strong compression, made at the same time on the whole thorax, and parietes of the abdomen, from which arises an equal impossibility of dilatation, both according to the transversal and perpendicular diameters of the breast; a sudden injection of a large quantity of fluid into this cavity, &c., are the causes which bring on the death of the lungs by the mechanical phenomena. Those which exert their first influence on the chymical phenomena, are, asphixia from the different gasses, by strangulation, submersion, or by a vacuum produced in any manner, &c.

We shall investigate how the death of the heart happens, in both these kinds of death in the lungs.

SECTION I.

Why the heart ceases to act by the interruption of the mechanical phenomena of the lungs.

The interruption of the action of the heart can succeed to that of the mechanical phenomena of the lungs, but in two ways, 1st, directly, because the blood finds a real mechanical obstacle to its circulation in this organ; and 2d, indirectly, because the lungs ceasing to act mechanically, it no longer receives the necessary aliment to its chymical phenomena, the termination of which brings on that of the contraction of the heart.

All physiologists have admitted the first mode of interruption in the pulmonary circulation. Turned back upon themselves, the vessels were not conceived in a situation to transmit the blood on account of the numerous frictions it would experience. It is by this explanation borrowed from hydraulic phenomena, that they have accounted for the death, which succeeds to expiration too much prolonged.

Goodwyn has proved that the quantity of air then remaining in the air vesicles, may distend them sufficiently to admit the mechanical passage of this fluid, and that therefore this preternatural protraction of the expiration does not act in the manner generally believed. This is one step towards the truth; but we may approach still nearer, and indeed attain it by assuring ourselves, that it is not only because all the air is not driven from the lungs by the expiration, that the blood still circulates in them with facility, but because the folds made in the vessels by the sinking of the cells, cannot be any real obstacle to its course. The

following observations and experiments, I think, incontestably establish this fact.

1. I have proved elsewhere, that the state of plenitude or vacuity of the stomach, and of all the hollow organs in general, creates no apparent change in their circulation; and that consequently the blood runs through the vessels which are folded or doubled on themselves as easily as when they are distended in every sense. Why should a totally different effect proceed from the same disposition of parts in the lungs?

2. There are various vessels in the animal economy, that may be alternately and at will, bent or distended in every direction: such are those of the mesentery, when they have been uncovered by a wound made in the abdomen of an animal. In this experiment, which has been already made to prove the influence of the crooked direction of the arteries upon the mechanism of their pulsation, if one of the mesenteric arteries is opened, and folded and unfolded by turns, the blood will spirt out with the same facility in either case, and in two equal times the artery will pour out an equal quantity of this fluid. I have repeated several times comparatively this double experiment upon the same artery; and always with the same result. Must not this result be also uniform in the lungs? Analogy would indicate it; and the following experiment proves it.

3. Take any animal, a dog for example; adapt the tube of a syringe to his trachea-arteria laid bare and cut transversely; draw it out suddenly, after emptying the lungs with it of all their air; and at the same time open the carotid artery. It is evident that in this experiment, the circulation should be suddenly interrupted, since the pulmonary vessels pass all at once from their ordinary degree of extension to the greatest possible involution, and yet the blood still con-

tinues for some time to be thrown out with force by the open artery, and consequently to circulate through the collapsed lungs. It ceases then by degrees; but it is from other causes which we shall point out.

4. The same effect may be produced by opening, on both sides, the thorax of a living animal: the lungs then sink immediately, because the heated and rarefied air contained in this organ, cannot maintain an equilibrium with the fresh air which presses upon it from without.* In this

* As in dead bodies the air within, is at the same temperature as that without, the lungs when full of it, experience no sinking when the pectoral cavity is opened. There is then ordinarily a space existing between the organ, and its enclosing walls: this is not because we die in expiration; for in proportion as the lungs are evacuated by it, the ribs and intercostal muscles rest upon this organ; it is that the pulmonary air, as it cools, occupies less space, and that the cells by closing gradually, as the cold takes place, diminish the total volume of the organ. A vacuum is therefore then created between the pectoral and pulmonary portions of the pleura.

It is thus that, in certain circumstances, by the sinking of the brain and diminution of its volume after death, while the cavity of the cranium remains the same, a vacuum is established between these two parts, which then present a disposition entirely different from that of the living organs. If the unopening sacs which are represented by the peritoneum, tunica vaginalis, &c. never therein resemble those that are formed by the pleura, and tunica arachnoidea; if their different surfaces are always contiguous after death, it is because the parietes of the abdomen, or the skin of the scrotum, incapable of resisting the external air, sink under its pressure, and apply themselves to the internal organs in proportion as the diminution of the latter tend to form the vacuum.

It is to this vacuum existing in the pleura of dead bodies, that the following phenomenon must be referred, which is always observed upon opening the abdomen, and dissecting the diaphragm. Indeed, so long as no opening is made in this muscle, it remains distended and concave, in spite of the weight of the pectoral viscera, which rest upon it in a perpendicular situation, because the external air which presses on its concavity, pushes it up into the cavity of the breast, which never exists during life. But let access be given to the air, by a stroke with the scalpel, and this muscular partition sinks in an instant, because an equi-

case also the circulation experiences no influence from this sudden change; it still keeps up for some minutes at the

librium is established. If all the air is evacuated from the lungs with a syringe, the diaphragmatic arch will become more distinct.

There is therefore this difference between the opening of a dead body, and that of a living subject, that in the first the lungs are previously sunk, and in the second, they sink at the moment of the opening. The contraction of the cells, when the cooled air is condensed, and made to occupy less space, is an effect of the contractibility of texture, *or by defect of extension*, which, as we have said, still partly remains to the organs after their death.

Besides, if the lungs sink in the dead body, at the moment of opening the thorax, it would be because of the pressure made by the external air, which pressure would expel through the trachea-arteria, that contained in this organ. Now if, with a view to prevent the escape of this fluid, you hermetically close the canal by adapting to it a tube, with the spigot stopped, and then open the thorax, the lungs will be found equally sunk· the air therefore must have already escaped. Make the same experiment upon a living animal, on the contrary, and you may always prevent the sinking of this organ by guarding against the expulsion of the air.

In this respect, Goodwyn has set out on a false principle, to ascertain, from the dead body, the quantity of air remaining in the lungs, after each expiration. Besides, whoever has opened even a few subjects, must be convinced that they seldom find two with the lungs in the same disposition. The infinite variety of ways in which life is terminated, by accumulating more or less blood in this organ, and retaining there more or less air, &c. creates such varieties in the volume, that no general datum can be established. On the other hand, can we expect to be more fortunate with respect to the living animal? No; for who is not aware that digestion, exercise, repose, the passions, the calm of the mind, sleep, watchfulness, temperament, sex, &c. create infinite varieties, in the powers of the lungs, the rapidity of the blood which goes through them, and in the quantity of air which enters them. All the calculations upon the sum of this fluid, which enters or leaves the lungs, at each inspiration or expiration, appear to me to be physiological misconstructions, inasmuch as they assimilate the nature of vital to physical powers. They are likewise as useless to science, as those which heretofore had for their object muscular force, the velocity of the blood, &c. And you will find, moreover, that their authors agree among themselves no better, than did others heretofore, upon that much agitated question.

same degree, and is at last only gradually enfeebled. For the sake of greater accuracy, the little air remaining in the vesicles may be pumped out with a syringe, and the same phenomenon will be equally observed in this case.

5. Along with these considerations, we may mention, as accessories, the continuance and facility of the pulmonary circulation in watery, purulent or bloody collections, whether of the pleura or pericardium, some of which so prodigiously compress the air-vesicles, and consequently twist the vessels of their parietes in so manifest a manner; we shall then have sufficient data upon which to conclude that the bending disposition of the vessels can be no obstacle to the passage of the blood through them; and that consequently the interruption of the mechanical phenomena of respiration does not directly produce a cessation of action in the heart, but that it suspends it indirectly, because the chymical phenomena can no longer be exercised, for want of the aliment to support them.

If then we explain how, when these last phenomena are destroyed, the heart remains inactive, we shall have resolved a double question.

Several authors have admitted as the cause of the death which follows a prolonged inspiration, the mechanical distension of the pulmonary vessels by the rarefied air, which distension prevents the circulation in them. This cause is not more real than that of the twisting or bending of the vessels after expiration. Distend the lungs by a quantity of air greater than that of the strongest inspirations; confine this air in the air-cells, by closing a cock fitted to the trachea-arteria; and then open the carotid: you will still see the blood run with an impetuosity equal to that when respiration is perfectly free; it is only by little and little that its flow is retarded, whereas it would become suddenly interrupted, if this cause, which acts in a sudden manner, was really the one which stops the blood in the vessels.

SECTION II.

Explanation how the heart ceases to act by the interruption of the chymical phenomena of the lungs.

According to Goodwyn, the only cause of the cessation of the contractions of the heart, when the chymical phenomena are interrupted, is the defect of excitement of the ventricle with red blood, which does not meet with a sufficient stimulus in the black blood; so that, according to his mode of considering asphixia, death then happens only because this cavity can no longer transmit anything to the different organs. It supervenes nearly as in a wound of the left ventricle, or rather as from a ligature on the aorta at its exit from the pericardium. Its principle and its source are exclusively in the heart. The other parts die only from the want of receiving blood; somewhat as when the principal spring of a machine is stopped, all the rest cease to act, not of themselves, but because they are no longer *put into action.*

I believe, on the contrary, that in the interruption of the chymical phenomena of the lungs there is a general affection of all the parts, that the black blood, driven every where, carries weakness and death to every organ that it enters; that it is not from their not receiving blood, but from their not receiving red blood, that each organ ceases to act; and that, in a word, all are then penetrated by the material cause of their death, namely, black blood; so that, as I shall say, we may produce asphixia in any part individually, by driving this fluid into it through an opening made in the artery, while all the other parts receive red blood from the ventricle.

I refer to the following articles to prove the effect of the contact of black blood upon all the other parts; in this I shall confine myself to inquire into the phenomena of its contact upon the walls of the heart.

The motion of the heart may be retarded and stopped by the influence of the black blood, in two ways: 1st, because, as Goodwyn has said, the left ventricle is not excited by it in its internal surface; 2nd, because, carried into its texture by the coronary arteries, this fluid hinders the action of its fibres, and acts upon them as upon all the other parts of the economy, by enervating their force, and their activity. But I believe that the black blood, as well as the red, may produce in the internal surface of the *aortic* ventricle, a sufficient excitement to force it to contract. The following observations appear to confirm this assertion.

1. If asphixia possessed such an influence over the functions of the heart, it is evident its phenomena should always commence by the cessation of action in this organ, and that the annihilation of the functions of the brain should be only secondary, as happens in syncope, when the pulse is immediately suspended, and when, for the same reason, the cerebral action is interrupted.

Notwithstanding, bring on asphixia in an animal, by stopping up the trachea-arteria, placing him in a vacuum, opening his thorax, or by plunging him into carbonic acid gas, &c. you will constantly observe that animal life is first interrupted, that the sensations, perception, voluntary locomotion and voice are suspended, that the animal is *externally* dead, but that the heart still beats for some time, that the pulse is kept up, &c.

What happens here, therefore, is not what is observed in syncope, where the brain and heart are stopped at the same time, but what is remarked in those violent commo-

tions where the second for some minutes survives the first. It follows then that the different organs do not cease to act in asphixia, because the heart no longer sends them blood, but because it sends them a species of this fluid to which they are not accustomed.

2. If the trachea of an animal is closed, while an artery remains open, the blood will be seen to grow gradually darker, and to become at last as black as venous blood. But, notwithstanding this appearance which is very observable, the fluid still continues for sometime to spirt out with a force equal to that of the red blood. There are some instances of dogs that, in this experiment, lose by the open artery, a sufficient quantity of black blood to make them die from the hemorrhagy, if death was not already brought upon them by asphixia.

3. It may be thought that some portion of respirable air, remaining in the visicles as long as the black blood continues to run, still communicates to it some principles of excitement: but to be assured that the venous blood passes into the ventricle with red blood, let all the air be pumped from the trachea-arteria, first laid bare and cut transversely for the purpose of adapting the cock; then let any artery be opened, the carotid, for example, as soon as the red blood contained in this artery shall be evacuated, the black blood will succeed to it all at once, and without passing through different shades of colour as in the preceding case; this stream continues also for sometime; and is lessened only by degrees; whereas, if the black blood was not an excitement to the heart, its interruption would be sudden in this case, when the blood can experience no kind of alteration in the lungs, and when it is the same in the aorta as it was in the venæ cavæ.

4. Here is another proof of the same kind. Lay bare one side of the thorax only, by sawing the ribs exactly

before and behind; the lung on this side instantly sinks while the other remains distended. Open one of the pulmonary veins; fill a syringe heated to the temperature of the body, with black blood taken from a vein of the same animal, or from another; throw this fluid into the auricle and ventricle with red blood: it is evident that its contact should, according to the common opinion on asphixia, not entirely destroy the motion of these cavities, since they receive red blood at the same time from the other lung, but at least diminish it in a sensible manner. Yet I have not observed this phenomenon in four successive experiments; in one indeed, an increase of the palpitation was observed, at the moment I pressed the piston of the syringe.

5. If the black blood is not a stimulus to the heart, while the red blood produces its contraction, it appears to be on account of the greater quantity of carbon and hydrogen it contains, since in this consists their principal difference. But, if the heart has ceased to beat in an animal killed expressly by a wound in the brain or lungs, so long as it preserves its irritability, the exercise of this property might be reestablished by blowing into the ventricle and auricle with red blood by means of the aorta, or one of the pulmonary veins, either hydrogenous or carbonic acid gas. Neither carbon nor hydrogen therefore act upon the heart as sedatives.

The experiments that I made and published last year, upon the emphysema produced in different animals with these two gasses, have equally established this truth as to the other muscles, since their motions do not cease in these experiments, and irritability remains to them as usual after death.

In fine, it has frequently happened to me, to restore the contractions of the heart, destroyed in different violent deaths, by the contact of black blood injected into the

ventricle and auricle with red blood, with a syringe adapted to one of the pulmonary veins.

The heart with red blood may then also drive forward the black blood into all the parts, and hence that colouration of the different surfaces as in asphixia, of which I shall speak minutely in one of the following articles.

The simple contact of the black blood does not act upon the internal surface of the arteries in a more sedative manner. In fact, if, while the cock adapted to the trachea-arteria is closed, the blood is suffered to run from one of the vessels, the most distant from the heart, from one of those of the foot, for example, it still flows out for some time with a force equal to what it had when the cock was open, and when of course it was red. The action exerted throughout its whole course from the heart upon the arterial coats, does not therefore diminish the energy of these coats. When this energy is enfeebled, it, at least in great part, arises from different causes.

We may conclude from the experiments of which I have just related the results, and from the accompanying considerations, that the black blood arriving in mass at the ventricle with red blood, and in the arterial system, may, by its contact alone, produce their action, irritate their internal surface, as has been said, and prove a stimulus to them; that if no other cause impeded their functions, the circulation would continue, if not perhaps with altogether as much force, at least in a very sensible manner.

What are the causes then which interrupt the circulation in the heart with red blood and in the arteries, when the lungs send out black blood to them? (for, when the latter has flowed for some time, its stream is gradually lessened, ceases at last almost entirely; and if the cock adapted to the trachea-arteria, is then opened, it is soon restored with force.)

I believe that the black blood acts upon the heart as well as upon all the other parts, as we shall find that it influences the brain, the voluntary muscles, the membranes, and in a word, all the organs over which it extends, that is to say, by penetrating its texture, and debilitating each fibre individually; so that I am well persuaded if it were possible to propel the black blood through the coronary artery, while the red passed as usual into the *aortic* auricle and ventricle, the circulation would be almost as soon interrupted as in the preceding cases, where the black blood does not penetrate the texture of the heart by the coronary arteries, until after having passed through the two cavities with red blood.

It is by its contact with the fleshy fibres, at the extremity of the arterial system, and not by its contact on the internal surface of the heart, that the black blood acts. It is also only by degrees, and after each fibre has been well penetrated with it, that its force diminishes and at last ceases, while the diminution and cessation should be almost sudden in the contrary case, as I have remarked.

How does the black blood act thus, at the extremity of the arteries, and upon the fibres of the different organs? is it upon these fibres themselves or upon the nerves which go to them, that it exerts its influence? I should be rather inclined to admit the last opinion, and to consider death by asphixia, as an effect generally produced by the black blood upon the nerves which, in all the parts accompany the arteries in which this fluid circulates. For, after what we shall say, the weakness that the heart then experiences is only a particular symptom of that disease in which all the other organs are the seat of a similar debility.

It might be asked also how the black blood acts upon the nerves or upon the fibres. Is it by the principles which

it contains in abundance, that it directly weakens the action, or is it only by the absence of those principles which enter into the composition of the red blood, &c.? Here the questions recur, whether oxygen is the principle of irritability, or whether carbon and hydrogen act in an inverse manner, &c.

Let us not go beyond the limits of rigorous observation; nor seek to penetrate farther than experiments can guide us. But I believe we may establish a position conformable to these principles (the only ones, in my opinion, which should govern a man of understanding) by saying in general, and without determining how, that the heart ceases to act when the chymical phenomena of the lungs are interrupted, because the black blood which penetrates its fleshy fibres is not proper to maintain their action.

According to this mode of regarding the phenomena of asphixia, relatively to the heart, it is evident that they must equally exert their influence upon both ventricles, since the black blood is then distributed in equal proportion in the fleshy walls of these cavities, by the system of coronary arteries. However it is almost constantly observed that the side with red blood first ceases to act, and that that with black blood still contracts for some time, that it is, as is said, the *ultimum moriens*.

Does this phenomenon suppose a more real debility, or a quicker death in the one than in the other of these cavities of the heart? No; for as Haller has observed, it is common to all kinds of death of animals with warm blood, and not particular to asphixia.

If, besides, the ventricle with red blood was the first to die, as the theory of Goodwyn supposes, then the following appearances would necessarily occur on the opening of bodies dead of asphixia: 1st, A distension of this ventricle and the corresponding auricle, by the black blood

which they would not have been able to force into the aorta; 2nd, An equal plenitude of the pulmonary veins and lungs also; 3rd, The consecutive *engorgement* of the pulmonary artery and of the cavities with black blood. In short the congestion of the blood should commence in that one of its reservoirs which first ceases its action, and then extend one after another to the rest.

Whoever has opened bodies dead of asphixia, must have been convinced, on the contrary, 1st, That the cavities with red blood and the pulmonary veins then contain only a very small quantity of black blood, in comparison of the quantity of the same fluid which distends the opposite cavities; 2nd, That the term where the blood is principally stopped is in the lungs, and that it is from these we must set out to follow its *stasis* in the whole venous system; 3rd, That the arteries inclose altogether as much in proportion as their corresponding ventricle, and that therefore it is not in the ventricle rather than elsewhere that death commenced.

Why then does this portion of the heart cease to beat before the other? Haller has said, it is because the latter is for a longer time excited, and contains a greater quantity of blood, which flows from the veins and retrocedes from the lungs. The experiment is well known by which, by emptying the cavities of black blood, and tying the aorta to retain this fluid in the pouches of red blood, the pulsation of the second has been prolonged much beyond that of the first. Now, in this experiment, it is manifest that it is the black blood which accumulates in the *aortic* auricle and ventricle, since to perform it, it is necessary first to open the breast, and that when the lungs are bare, the air not being able to penetrate it, cannot colour this fluid in its passage through the texture of its organs.

If a more direct proof is wished for: close the trachea-arteria by means of a stop-cock, immediately before the

experiment; it will succeed equally well, and the blood will then necessarily arrive black into the cavities of red blood. We may easily be made certain of the colour of the blood, upon opening these cavities at the end of this and the preceding experiment. I have several times verified this remarkable fact.

We may hence conclude that the black blood stimulates, nearly as much as the red, the internal surface of the cavities which ordinarily contain the latter, and that if they cease their action before those of the opposite side, it is not because they are in contact with it, but on the contrary, because they do not receive it in sufficient quantity, or because they are sometimes also almost entirely deprived of it, while the cavities of black blood are replete.

I do not presume, notwithstanding what I have just said, to reject entirely the non-excitement of the internal surface of the ventricle of red blood by the black. It is possible that the latter may be a little less susceptible than the other of keeping up this excitement, particularly if it be true that it acts upon the nerves which it is known are spread over the internal surface and texture of the heart; but I believe that the preceding considerations reduce to a mere trifle this difference of excitement. In the following experiment, however, it appears plain enough. If a stop-cock is adapted to the trachea-arteria cut and laid bare, and the stop closed, the blood grows black and spirts out of that colour for some time with its usual force; but at last the jet is gradually weakened. Give access to the air again; and the blood resumes its red colour almost on the instant, and its jet is also very visibly augmented.

This sudden augmentation appears at first to depend only on the simple contact of this fluid on the internal surface of the *aortic* ventricle, since it has not had time to penetrate its texture. But if an attentive examination

is made, it is soon observed that this impetuosity of impulsion proceeds from the air, which, rushing into the breast, determines the animal to violent motions of inspiration and expiration, which become very apparent at the moment the cock is opened. Now the heart, excited on the exterior, and perhaps a little compressed by these motions, then expels the blood with a force much beyond its usual contractions.

The truth of what I advance is so evident, that when inspiration and expiration recover their ordinary degree, the jet, though still red manifestly diminishes; it is not more strong or copious than that of the black blood in the first moments of its running, and before the texture of the heart was penetrated with this fluid.

Besides, the influence of strong expirations upon the projectile force of the heart is very manifest, without touching the trachea-arteria. Open the carotid; and quicken the respiration by causing the animal to suffer a good deal, (for I have constantly observed that all sudden pain produces this change in the action of the diaphragm and intercostals;) quicken the respiration, I say, and you will see the jet of blood then manifestly augmented. You may often also artificially produce this augmentation, by compressing the pectoral walls suddenly and violently. These experiments succeed best in animals already weakened by the loss of a certain quantity of blood; they are less apparent in those taken before this circumstance.

I am unable to explain why violent expirations voluntarily made in a natural state do not render the pulse stronger, since they very often increase the stream of blood.

It follows from what we have just said, that the experiment in which the blood grows red and spirts out to a

distance, the instant the cock is opened, is not so conclusive as it at first appeared to me; for this result embarrassed me for several days, inasmuch as it bore no connexion with the greater part of those which I obtained.

We must still therefore acknowledge, that if the irritation produced by the red blood on the internal surface of the heart, is somewhat more considerable than that produced by the black, the excess is scarcely observable, and that the interruption of the chymical phenomena acts principally in the manner I have pointed out.

In animals with red and cold blood, in reptiles particularly, the action of the lungs is not in so immediate a state of connexion with that of the heart, as in animals with red and hot blood.

I have tied the lungs by their *radix* in two frogs, after having laid them bare by two lateral incisions made in the breast; the circulation continued as usual for a long time. Upon opening the breast, I have sometimes also seen the motion of the heart quickened after this experiment, which, no doubt, proceeded from the contact of the air.

I shall finish this article with the examination of the important question, how, when the chymical phenomena of the lungs are interrupted, the pulmonary artery, the ventricle and auricle of black blood, and in a word, the whole venous system are found gorged with blood, while much less is met with in the vascular system with red blood, which nevertheless contains more than in most other deaths. The lungs appear, indeed, to be then the term where the circulation finishes and is afterwards stopped in all the other parts, one after another.

This phenomenon must have been observed by all who have opened bodies dead of asphixia. Haller and others explain it by the involutions of the pulmonary vessels: I have said what credit ought to be attached to this opinion.

Before we point out a more real cause, we must remark that the lungs where the blood stops, because they offer the first obstacle to this fluid, afford singular varieties in their state, according to the manner in which life is terminated. When death has been quick and instantaneous, then this organ is not all engorged; the auricle and ventricle of black blood, the pulmonary artery, the venæ cavæ, &c. are not much distended.

I have observed this fact, 1st, In the bodies of two persons who had been hanged; 2nd, In three subjects who had been suffocated by falling into the fire; 3rd, in dogs that had been suddenly drowned, or in which respiration was all at once interrupted by a stop-cock adapted to the trachea-arteria; 4th, In guinea pigs, that were suffered to die in vacuo, in different gasses, the carbonic particularly, or in which the aorta was tied at its origin from the heart, or in which the thorax was simply opened to interrupt the mechanical phenomena of respiration: for in this last circumstance it is as I have observed, because the chymical phenomena cease, that the heart no longer acts, &c. In all these cases the lungs were not gorged with blood.

On the contrary, cause the chymical phenomena of respiration in an animal to cease, in a slow and gradual manner; drown it by alternately plunging it into and drawing it out of the water; produce asphixia in it by placing it in a gas into which a little common air is suffered to enter from time to time, or by not closing completely a cock fixed in the trachea-arteria; in fine, by prolonging, as far as possible, this state of torture and anguish, which, in the interruption of the functions of the lungs, is intermediate to life and death; you will always observe this organ glutted with blood, and having a volume double that which it presents in the preceding case.

Between the extreme *engorgement* and the almost complete vacuity of the pulmonary vessels, there are infinite degrees; we may produce any of these degrees, according to the manner in which we cause the animal to perish: I have very often observed it. It is thus we must explain the state of fulness of the lungs in all subjects whose life has been terminated by long agony, or any affection slow in its progress: the greater part of the bodies brought into our amphitheatres present this disposition.

But whatever may be the state of the lungs in asphixia, whether they be found replete or void of blood, whether death has been slowly or suddenly produced; the vascular system of black blood is always full of this fluid, particularly about the heart; there is always in this respect a great difference between this and the vascular system of red blood; and it is consequently always in the lungs that the circulation meets with its principal obstacle.

From what cause then can this obstacle arise, since it is not produced by the convolutions of the organ, as we have seen? these causes are relative, 1st, to the blood, 2nd, to the lungs, and 3rd, to the heart.

The principal cause relative to the blood, is the great quantity of this fluid, which then passes from the arteries into the veins. In fact, we shall soon see that the black blood circulating in the arteries, is not capable of furnishing to the secretions, to the exhalations, and to nutrition, the different materials necessary to these functions, or that if it does bear these materials, it cannot excite the organs, but leaves them inactive.*

* *Vide* the article on the influence of the lungs upon all the parts. I am obliged here to deduce inferences from premises which must remain to be proven in the sequel: such indeed is the catenation of questions embraced by the circulation, that it is impossible the solution of one should lead as a necessary consequence to that of all the others. It is a circle in which it is always necessary to suppose something, and leave it to be proved afterwards.

It follows from this that the whole portion of this fluid, ordinarily taken from the arterial system by these different functions, reflows into the venous system with that portion which passes into it naturally, and which is the residuum of what has been employed: hence a quantity of blood much greater than in the customary state; and hence consequently the many more difficulties which this fluid finds in passing through the lungs.

All practitioners who have opened bodies dead of asphixia, have been struck with the abundance of blood met with in them. M. Portal has made this observation; and I have constantly verified it in my experiments.

The causes relative to the lungs, which, in cases of asphixia, impede the circulation of the blood in this organ, are, in the first place the defect of excitement by the red blood; indeed, the bronchial arteries which generally convey this fluid, then only carry thither black blood; hence the dark brown colour of the lungs, when the animal is by any means prevented from breathing. This colour is seen particularly, and its successive shades well distinguished, when, upon the breast being opened, the air cannot penetrate into the collapsed air-vesicles, to redden the blood which still circulates in them.

The blackness of the blood of the pulmonary veins concurs also, and indeed more effectually, considering its greater quantity, to this colouration, which should be distinguished from those bluish spots natural to the lungs of certain animals.

The black blood circulating in the bronchial vessels, produces the same effect upon the lungs, which in the heart, arises from its contact, when it penetrates this organ by the coronaries: it enervates the different parts, impedes their action and the capillary circulation which is carried on there under the influence of their elastic powers.

The second cause which, in the interruption of the chymical phenomena of the lungs, constrains the circulation of this organ, is the defect of excitement by vital air. The first effect of this air reaching the mucous surfaces of the air-vesicles, is to excite them, to stimulate them, and consequently to keep the lungs in a kind of continual erection: thus the food upon its arrival in the stomach, excites its powers; and thus are all the reservoirs irritated by the contact of their accustomed fluids.

This excitement of the mucous membranes by foreign substances in contact with them, supports their tonic powers, which when this contact is annihilated, partly decline and consequently leave the capillary circulation less active.

The different aeriform fluids which make up the atmospheric air in the various cases of asphixia, appear to act in very various degrees upon the tonic powers, or upon the insensible organic contractibility. Some depress them almost suddenly, and put a stop at once to the circulation, while others suffer it to go on for a longer or shorter time. Compare the asphixia produced by the nitrous, sulphurated hydrogenous gas, &c. to that by pure hydrogen, carbonic acid gas, &c. and you will observe a remarkable difference. This difference, as well as the various effects which follow different kinds of asphixia, depend also, as we shall see, upon other causes; but this evidently has considerable influence.

Lastly, the cause relative to the heart, which in cases of asphixia produces a stagnation of the blood in the venous vascular system, is the debility of the ventricle and auricle of this system, which, penetrated in every fibre by the black blood, are no longer capable of throwing out this fluid towards the lungs with energy, and of surmounting thereby the resistance it there meets with: they remain, therefore, distended by it, and can no longer resist the

entrance of that poured into them by the venæ cavæ. These as well as the whole venous system swell, because their coats ceasing to be excited by the red blood, and being entirely pervaded with the black, lose by degrees the requisite spring to their functions.

From all that has been just said, it is easy to conceive why the whole vascular system with black blood is found replete with this fluid in asphixia.

It will be learned also, by the following considerations, why the system with red blood contains a smaller quantity.

1. As the obstacle commences in the lungs, this system evidently receives much less than usual; hence, as we have seen, the quicker cessation of the contractions of the left ventricle.

2. The natural force of the arteries, though weakened by the ingress of the black blood into the fibres of their coats, is nevertheless much superior to that of the venous system, subject moreover to the same cause of debility; consequently these vessels and the *aortic* ventricle can much more easily surmount the resistance of the capillaries of the whole body, than the veins and venous ventricle can overcome that of the capillaries of the lungs.

3. In the general capillary circulation there is but one cause of abatement, namely, the contact of black blood upon all the organs, whereas in the lungs, to this cause is added the absence of the accustomed excitement produced in it by the atmospheric air. In the lungs therefore, on the one hand, more resistance is offered to the blood carried thither by the veins, and on the other hand, less power to surmount this resistance; while in all the parts on the contrary, at the termination of the arteries, and at the passage of their blood into the veins, there are on the one hand more feeble obstacles, and on the other hand, greater power to overcome these obstacles.

4. In the general capillary system, which is the termination of that of the arteries, if the circulation is embarrassed at first in a particular organ, it may be carried on still for a little in the others, and thus the blood reflows into the veins. On the contrary, as the whole capillary system which terminates the veins, is concentered in the lungs, if this organ loses its powers, its sensibility and insensible organic contractibility, it then necessarily follows that the whole venous circulation should be stopped.

The preceding considerations, I think, afford an explanation of the inequality in the plenitude of the two vascular systems, an inequality which is not only found in bodies dead of asphixia, but which is also more or less observable after almost all diseases.

Though the general capillary system offers less resistance to the arteries in asphixia, than the pulmonary capillary system does to the veins, yet this resistance, (created particularly by the ingress of black blood into all the organs the powers of which it is not capable of supporting,) is very manifest, and it produces two phenomena somewhat remarkable.

The first is the stagnation of a quantity of black blood in the arteries, much more considerable than usual, though nevertheless much smaller than in the veins. Hence the great difficulty of making injections in bodies which have died of asphixia, which generally succeed better in proportion as the arteries are more empty: the blood which is then found in them is fluid, and rarely clotted, because it is venous, and that the more it bears this character, the less easily is it coagulable, as is proved, 1st, By the experiments of modern chymists; 2nd, By the comparison of that found in *varices*, with that contained in aneurisms; 3rd, By inspection of that which is usually found after death in the veins in the vicinity of the heart, &c.

The second phenomenon in asphixia, arising from the resistance which the enfeebled capillary system opposes to the arteries, is the livid colour observed in most of the surfaces, and the turgidity of the different parts, as of the face, tongue, lips, &c. These two phenomena indicate a stagnation of the black blood in the arterial extremities which it cannot pass through, and they denote the same effect in the pulmonary vessels, where the turgidity is much more manifest, because, as I have said, the capillary system is concentrated there in a very small space, while at the arterial extremities it is largely disseminated.

All authors refer the livid colour of persons destroyed by asphixia, to the reflux of the blood from the veins towards the extremities; this cause has not much reality. In fact, this reflux which is very sensible in the truncs, constantly diminishes towards the ramifications, where the valves render it nugatory, if not impossible.

The following experiment clearly proves that it is to the impulsion of the black blood transmitted by the *aortic* ventricle into all the arteries, this colouration should be attributed :

1st, Adapt a tube with a cock to the trachea-arteria laid bare and cut transversely above; 2nd, open the abdomen in such a manner as to distinguish the intestines, epiploon, &c. and 3rd, shut the cock. At the end of two or three minutes, the reddish tint observable on the white bottom of the peritonæum, and which this membrane derives from the vessels creeping underneath it, will change to a dark brown, which you may cause to appear and disappear at will by opening or shutting the cock.

A reflux from the right ventricle towards the venous extremities cannot be suspected here, as if the experiment was made upon other parts; since the mesenteric veins along with the other branches of the vena porta form a

system apart, independent of the great system of black blood, and without any communication with the cavities of the heart which correspond to this system.

I shall recur hereafter to the colouration of the parts by the black blood; this experiment is sufficient to prove that it is a manifest effect of the arterial impulsion, which is exerted upon this fluid foreign to the arteries in their ordinary state.

It is easy from what we have said, to explain why the lungs are more or less gorged with blood, and more or less brown; and why the livid spots spread over the different parts of the body are more or less distinct, according as the asphixia has been produced more or less suddenly.

It is evident, that if the black blood has completed its circulation through the two systems ten or twelve times before death, their extremities will be much more bloated, than if it has only passed through them two or three times, since at each time there remains a greater or less quantity in these extremities by the defect of action in the capillary vessels.

I must observe, before the conclusion of this article, that the spleen is the only organ of the animal economy, susceptible, like the lungs, of assuming different volumes. Scarce is it found twice in the same state. Sometimes very much swelled with blood, and sometimes nearly void of this fluid, it presents itself in different subjects under innumerable forms.

It has been falsely thought that there was a connexion between the fulness or vacuity of the stomach and the inequalities of the spleen. Experiments have taught me the contrary, as I have said elsewhere; these inequalities, totally foreign to life, appear to take place only at the moment of death.

I believe that they depend especially on the state of the liver, the capillary vessels of which are the termination of all the truncs of the vena porta, as the capillaries of the lungs are that of the venous system; so that when the hepatic capillaries are debilitated by any cause, the spleen must be necessarily swelled and filled with blood which cannot find its way through the liver. An *isolated* asphixia, if I may thus express myself, then takes place in the abdominal vascular apparatus.

In this case the liver is to the spleen, what the lungs are to the cavities with black blood in ordinary asphixia: it is in the first organ the resistance is met with; and in the second the stagnation of the blood takes place. But this may be elucidated by experiments on animals killed in different ways. I propose by this means to determine accurately, the analogy existing between the sojourn of the blood in the different branches of the vena porta, and that which is observed in the venous system generally, after different kinds of death. I have not observed any peculiarities in the spleen and its system of veins, in ordinary cases of asphixia.

It is useless to notice the necessity of distinguishing the turgidity of this organ by the blood which penetrates it at the moment of death, and which must have been observed by all who have opened dead bodies, from that which is sometimes produced in it, by different diseases. A slight view is sufficient to prevent the mistake.

ARTICLE VII.

OF THE INFLUENCE WHICH THE DEATH OF THE LUNGS EXERCISES ON THAT OF THE BRAIN.

WE have seen that it is by sending black blood into the fleshy fibres of the heart, and by acting perhaps on the nerves by the contact of this blood, that the lungs influence the cessation of the pulsations of this organ, in asphixia. This fact appears to anticipate a similar one in the brain; observation proves it indubitably.

Whatever may be the manner in which the pulmonary action is interrupted; whether the chymical or mechanical phenomena cease one before the other, these are always the first whose alteration spreads confusion throughout the cerebral functions. What I have said upon this head, with respect to the heart, is exactly applicable to the brain; it is therefore unnecessary to repeat it.

At present then we have only to show by experiment and by observation of diseases, that in the interruption of the chymical functions of the lungs, it is the black blood which interrupts the action of the brain, and, no doubt, that of the whole nervous system. Let us examine, in the first place, the experiments relative to this subject.

I commenced, in the first place, by transfusing into the brain of one animal, the arterial blood of another, that this experiment might serve as a term of comparison for the following. One of the carotids of a dog being opened, let a tube be fitted to it by the side of the heart, and that

portion correspondent to the brain tied; let the same artery then in another dog be cut; and let a ligature be placed above the opening into which must be fixed the other extremity of the tube. Let the assistant then, who held the carotid of the first dog, cease to interrupt the course of the blood, and it will be thrown with force by the heart of this animal towards the brain of the other: the pulsations of the artery which had ceased in the latter, above the tube, are immediately renewed, and indicate the course of the fluid. This operation does not much fatigue the animal that receives the blood, particularly if care is taken to open one of its veins, to avoid a too great plenitude of the vessels; it lives very well afterwards.

We may conclude then from this experiment, which has been often repeated, that the contact of extraneous red blood is in no way capable of altering the cerebral functions.

In the next place, I have adapted to the open carotid of one dog, sometimes one of the veins of another dog by a straight tube, and sometimes the jugular of the same dog by a curved tube, in such a manner that the black blood should get to the brain by the system of red blood. The animal, which was supposed to receive the fluid, experienced no uneasiness in several experiments, which astonished me the more, as their result did not accord with that of the trials made on the other organs. I at length perceived the reason of this: the black blood does not get to the brain in these experiments. The motion which is established in the superior part of the open artery, and which projects the red blood in a direction opposite to that in which it naturally runs, is equal and indeed superior to the venous impulsion which it overcomes, and of which it hinders the effect, as may be seen upon opening that portion of the artery above the tube which ought

to conduct the black blood into it. This motion appears to depend both upon the organic contractile powers of the artery and upon the impulsion of the heart, which causes the blood to reflow by the anastomoses, in a direction opposite to that which is natural to it.

It is necessary therefore to have recourse to some more active means of forcing this kind of blood into the brain. These means are very simple. I opened the carotid and the jugular of an animal; and received in a syringe heated to the temperature of the body, the fluid poured out by the latter, which I injected into the brain by the former, which had been tied on the side next the heart to avoid hemorrhage. The animal was almost immediately agitated; he appeared to be undergoing similar sufferings to those produced by asphixia; of which he very soon showed all the symptoms; animal life was entirely suspended; the heart still continued to beat, and the circulation to go on for half an hour, at the end of which time death terminated organic life also.

The dog was of the middle size, and about six ounces of black blood were injected with a moderate impulsion, lest what should have been the effect of the nature and composition of the fluid, might be attributed to the mechanical shock. I repeated this experiment upon three dogs successively in the same day, and afterwards at different times upon several others: the result was invariable, not only as to the asphixia of the animal, but also as to the phenomena which accompanied the death.

It may be thought that, upon leaving its vessels and being exposed to the contact of the air, the blood receives some pernicious principles from this fluid, or communicates to it those which were necessary to the support of life, and that the sudden death which supervenes when the blood is thrown into the brain is owing to this cause.

To clear up this doubt, I made a small opening in the jugular of a dog, to which was adapted the tube of a heated syringe, the piston of which I worked in such a manner as to pump the blood in the vein, without suffering the air to come in contact with it. It was forced immediately through an opening made in the carotid: and instantly the same symptoms manifested themselves as in the preceding cases; death supervened, but more slowly, it is true, and with less violent agitations. It is therefore possible that, when the air is in contact with the living blood, drawn from its vessels, it changes it a little, and renders it less fit to support the life of the solids; but the essential cause of death is always, after the preceding experiment, in the blackness of this fluid.

By this then it appears, that the black blood, either is not a stimulus capable of keeping up the cerebral action, or that it acts in a deleterious manner upon the encephalic organ. By throwing up different extraneous substances by the carotid, similar effects are produced.

I have killed animals by injections of ink, oil, wine, water coloured with common blue, &c. Most of the excrementitious fluids, such as the urine, bile, and the mucous fluids in catarrhal affections have also a mortal influence on the brain, by their simple contact.

The serous part of the blood, which separates from the coagulum in venæsection, produces death also, when artificially thrown into the brain; but its effects are slower, and the animal often survives the experiment for several hours.

Besides, it is very certainly by acting upon the brain, and not upon the internal surface of the arteries, that these different substances are fatal.

I have injected them all by way of comparison through the crural. Not one of them produces death in this way: I

have remarked only that a numbness or paralysis almost always succeeds the injection.

The black blood is no doubt fatal to the brain by striking it with atony by its contact, in the same manner with the different fluids of which I have spoken. What this manner is, I shall not attempt to inquire: for the investigation must begin with conjecture, at which I always choose to stop.

We are already, I think, authorized to believe that in asphixia, the circulation which continues for some time after the chymical phenomena of the lungs have ceased, interrupts that of the brain, by carrying to it black blood by the arteries. Another consideration proves it: that is, that the motions of this organ then continue as usual.

If the cerebral mass is exposed to view in an animal, and asphixia produced in it by any means, by throwing the different gasses into its trachea-arteria, for example, by closing the cock which has been adapted to it, it may be observed, that the whole animal life is already nearly destroyed, that the functions of the brain have consequently ceased, and that this organ is notwithstanding still agitated by alternate motions of elevation and depression, motions arising from the impulsion given by the black blood. Since then this cause of life still exists in the brain, its death must be owing to the nature of the fluid which penetrates it.

Nevertheless if any cerebral affection accompanies the asphixia, the death produced by the latter is quicker than in ordinary cases. Let an animal be first struck with commotion; and then deprived of air: his life which, in the first instance, would be only disturbed, will, in the second place, be suddenly extinguished. By causing asphixia in another animal already stupified by an artificial compression made on the brain, all the functions appeared to me also to cease a little sooner than when the brain is unmo-

lested during the operation. But we shall elucidate, by new experiments, the consequences deduced from those already presented.

If in asphixia the black blood suspends the cerebral action by its contact, it is clear that upon opening an artery in an animal in a state of asphixia, the carotid, for example, drawing this fluid thence, and injecting it with moderate force towards the brain of another animal, the latter must die also in a state of asphixia, after a little time. This is indeed what constantly happens.

Cut the trachea-arteria of a dog; and then close it hermetically. In a few minutes the blood runs black in the system of red blood. If you afterwards open the carotid, and receive what flows from the opening in a syringe, and throw it into the brain of another animal, the latter soon falls down, with interrupted respiration, sometimes with plaintive cries, and death very soon supervenes.

I have made one experiment similar to this, which however gave a somewhat different result. It requires two dogs, and consists, 1st, in adapting a cock to the trachea-arteria, and the extremity of a silver tube to the carotid, of the first; 2nd, in fixing the other extremity of this tube into the carotid of the second, on the side which corresponds to the brain; 3rd, in tying both the arteries on the side opposite to that in which the tube is fixed, in order to prevent hemorrhage; 4th, in suffering the heart of one of these dogs for an instant to throw red blood into the brain of the other; 5th, in closing the cock, and thus causing the black blood to succeed to what first flowed.

After a certain time the dog which receives the fluid, is stunned and agitated, lets fall his head, and loses the use of his external senses, &c. But these phenomena are slower in showing themselves, than when the black blood

is injected taken in the venous or arterial system. If the transfusion is stopped, the animal may be reanimated, and indeed live after the symptoms of asphixia are removed, whereas death is uniformly the result when a syringe is used to throw the same fluid, whatever may be the degree of force employed. Does the air then communicate any principle still more deleterious than that given to it by the elements which render it black ?

For this experiment, it is necessary that the dog whose artery forces on the blood, should be vigorous, and stouter than the other, because the impulsion is diminished in proportion as the heart is penetrated with black blood, and because, moreover, the tube slackens the motion, though notwithstanding this motion may be very sensible, and a manifest pulsation above the tube indicate the influence of the heart of the one, on the artery of the other.

I have endeavoured to render venous blood capable of supporting the cerebral action, by giving it an artificial red colour. For this purpose, I opened the jugular and the carotid of a dog: the one furnished me with a certain quantity of black blood which, received in a bottle filled with *oxygen*, became immediately a shining purple ; I injected it by the artery; but the animal died suddenly, and with a promptitude which I had not before observed. It may be conceived how far I was from expecting such a result. But my surprise soon vanished upon the following remark: a very great quantity of air was mixed with the fluid, which arrived at the brain very frothy and turgid. Now we have seen that a small number of air-bubbles produces death in animals, when introduced into the vascular system, whether carried to the brain or to the heart.

This induced me to repeat my experiments upon the injection of black blood, to see if any bubbles were mixed with it, and occasioned death : I have constantly observed

that this was not the case. Another difficulty presented itself to me: it is possible that the little air contained in the extremity of the tube of the syringe, and that which made its entrance by the open artery and forced by the injection towards the brain, was sufficient to destroy its action. But a little reflection removed this doubt. If this was the real cause, it ought to produce the same effect in the injection of every fluid, of water for instance: now nothing like it is observed with this fluid.

We may therefore, I think, be certain, that it is really by the nature of the principles which it contains, that the black blood is either incapable of exciting the cerebral action, or acts upon it in a deleterious manner; for I cannot say whether its influence is exerted negatively or positively; all I pretend to know is, that the functions of the brain are suspended by it.

From this datum it would appear that bodies in a state of asphixia might be reanimated by forcing red blood into the brain, which is its natural exciting cause. We should distinguish two periods in asphixia in this respect: 1st, that when the cerebral functions alone are suspended; and 2nd, that when the circulation is already stopped, as well as the motion of the breast; for this affection is always characterised by the sudden loss of the whole animal life, and afterwards by that of the organic, which follows consecutively. Now, so long as the asphixia is at the first period in an animal, I have observed that upon transfusing red blood towards the brain, by means of a tube adapted to the carotid of another animal, the motion is gradually reexcited; the cerebral functions resume their exercise in part, and often sudden agitations in the head, eyes, &c. announce the first ingress of the blood; but these symptoms soon disappear, and the animal again falls, if the cause of the asphixia continues, if, for instance, the cock adapted to the trachea-arteria remains shut.

On the other hand, if the cock is opened in this first period, the contact of fresh air on the lungs almost always gradually reanimates this organ. The blood is coloured, is thrown red to the brain, and life is recovered without the preceding transfusion, which never produces any effect in the animal when the asphixia is at its second period, that is to say, when the organic motions, those of the heart more especially, are suspended; so that this experiment only affords us a proof of what we knew already; namely the difference of the influence of the black and red blood upon the brain, and not a remedy against asphixia.

I observe further that it does not succeed after the injection of venous blood by a syringe. Then, though the cause of the asphixia has ceased after the injection, and though arterial blood is sent on by the same opening, whether by transfusing it from the artery of another animal, or injecting it after having received it from an open artery in a siphon, the animal shows but feeble marks of excitement; often none at all; and death is always inevitable.

In general, asphixia occasioned by blood taken from the venous system and forced into the brain is quicker, more certain, and very manifestly different from that produced in the lungs by the gradual change of the red blood into black, upon the interruption of the air, or the introduction of gas into the trachea-arteria, &c.

After having established, by various experiments, the fatal influence of the black blood upon the brain which receives it from the arteries on the interruption of the chymical phenomena of the lungs, it is not useless, I trust, to show that the phenomena of asphixia observed in man, accord very nearly with these experiments which may furnish hints for an explanation of them.

1st. It is very well known that every species of asphixia exerts its first influence on the brain; that the functions of this organ are in the first place annihilated; that animal life ceases, particularly with respect to sensations; that all connexion with what surrounds us is all at once suspended; and that the internal functions are interrupted only consecutively. Whatever may be the mode of causing asphixia, whether by submersion, strangulation, or vacuum, or by the different gasses, &c. the same symptom always manifests itself.

2nd. It is curious to observe how, in experiments in which asphixia is brought on an animal with an artery open, in proportion as the blood grows dark and black, the cerebral action is disturbed and is already almost annihilated, while that of the heart goes on still with energy.

3rd. It is known that most of those in a state of asphixia who escape suffocation, experience only a general stupor and drowsiness the seat of which is evidently in the brain, and that in all those in whom the pulse and heart can no longer be felt, death is almost certain. In numerous experiments, I have never seen the asphixia cured at this period.

4th. Almost all those who have recovered from this affection, particularly when it has been produced by the vapour of charcoal, say they first felt a more or less violent pain in the head, probably the effect of the first contact of the black blood upon the brain. This fact has been noticed by most of the authors who have written upon this subject.

5th. Do not the common expressions used by the sufferers in these cases prove that the first effect of the asphixia produced by the vapour of this substance, is felt in the brain and not in the heart? Common people, who are

prejudiced by no particular system, often make more correct observations than ourselves, who look only for what we wish to find corroborative of our previously formed opinions.

6th. There are various examples of patients who, after recovering from the state of asphixia into which the vapour of the charcoal had thrown them, retain for a longer or shorter time, different alterations in the intellectual functions and in the voluntary motions, alterations which evidently have their seat in the brain. For many days after the accident, if it has been carried to a certain degree, the patients stagger about, are not able to support themselves on their legs, and their ideas are confused. This is, in a smaller degree, what apoplexy presents in a higher. Sometimes convulsive motions manifest themselves almost immediately after the impression of the mephitic vapours. A pain in the head has sometimes lasted for several days after the disappearance of all the other symptoms. In the works of those who have made this subject their study, particularly in that of M. Portal, may be seen multiplied instances of the fatal and often long protracted influence of the black blood, when carried to the brain by the arteries.

This influence, though it does exist in animals with cold blood, in reptiles particularly, is however much less manifest. I have made two incisions in the sides of the thorax of a frog, so that the lungs came out on each side; I then tied them where the vessels enter them; and the animal has notwithstanding lived a very long time, though all communication was destroyed between the brain and the pulmonary organ. If instead of tying the latter, they are entirely extirpated, the same phenomenon takes place.

In fish, which differ essentially in the organization of the branchiæ from reptiles, the connexion between the

lungs and the brain has appeared to me rather more immediate, though notwithstanding much less than in the species with red and hot blood.

I have cut away the cartilaginous lamella which covers the branchiæ, in a carp: the latter when laid bare, moved alternately to and from the axis of the body. Respiration appeared to go on as usual, and the animal lived a very long time without any apparent disturbance in its functions.

I afterwards bound together, by a leaden wire, all the branchiæ and the cartilaginous rings which support them; this wire was tied in such a manner as to prevent all motion in the pulmonary apparatus. The carp very soon languished; its fins ceased to be extended; the muscular motion gradually diminished; soon ceased entirely, and the animal died in about fifteen minutes.

Very nearly the same phenomena took place in another carp, from which I took away the gills altogether; I observed only that the moment after the experiment, various irregular motions took place, after which the animal raised itself in the water, supported itself there as usual, lost a great deal of blood, and at length fell dead at the end of twenty minutes.

The peculiar kind of connexions, which unites the heart, the brain and the lungs in animals with red and cold blood, deserves, I think, the particular attention of physiologists. These animals should not be subject like those with red and hot blood, to swoonings, apoplexy and those other diseases in which death suddenly takes place by the interruption of these connexions; or at least the diseases in them similar to those, should bear other characters; asphixia in them is infinitely longer in its operation. Let us return now to the species approaching man.

After the influence of the black blood upon the heart, brain and all the organs, I considered that persons affect-

ed with varicose aneurisms, ought to suffer more slowly by asphixia than others, when deprived of air, because the red blood passing into their veins, goes through the lungs without the necessity of undergoing any alteration, and should, consequently keep up the cerebral action.

To assure myself if this supposition was well founded, I in the first place made a communication between the carotid artery and the jugular vein of a dog, by means of a curved tube, which carried the blood from the first into the second, and communicated to it a very apparent motion of pulsation. I then closed the cock previously adapted to the trachea-arteria of the animal; it appeared indeed to remain a longer time without experiencing the phenomena of asphixia; but the difference was not considerable, and in a second animal on which I repeated the same experiment, it was not at all observable.

We may conclude, I think, with certainty, from the different experiments and considerations laid down in this paragraph,

1st. That, in the interruption of the chymical phenomena of the lungs, the black blood acts upon the brain as upon the heart, that is to say, by penetrating the texture of this organ, and thus depriving it of the excitement necessary to its action;

2d. That its influence is much more ready upon the first, than upon the second of these organs;

3d. That it is the inequality of this influence which produces the difference in the cessation of the two lives, in asphixia, when the animal is always destroyed before the organic life.

We may also conceive, from what has been said in this and the preceding article, how improperly founded is the opinion of those who maintain that, in persons executed by the guillotine, the brain may live for some time, and

even retain the sensations of pain and pleasure. The action of this organ is immediately dependant upon its double excitement, first, by the motion, and secondly, by the nature of the blood which it receives. Now, this excitement being then suddenly annihilated, the interruption of every species of feeling must be sudden.

Though in the cessation of the chymical phenomena of the lungs, the disturbance of the cerebral functions has great influence on the death of the other organs, yet it is only the principle of it in animal life where other causes also are joined to this, as we shall see. Organic life ceases by the simple contact of the black blood upon the different organs. The death of the brain is but an individual and partial phenomenon of asphixia, which has its seat exclusively in no organ, but affects them all equally by the influence of the blood which it sends to them. This will be made apparent in the following article.

ARTICLE VIII.

OF THE INFLUENCE OF THE DEATH OF THE LUNGS UPON THAT OF ALL THE ORGANS.

I HAVE just explained how the interruption of the chymical phenomena of the lungs destroys the functions of the heart and brain. It remains to show that it is not only upon these two organs that the black blood exerts its influence, that all those of the animal economy receive a

fatal impression from it, when it is carried to them by the arteries, and that consequently asphixia is, as I have said, a general disease of all the organs.

I shall not recur to the division of the pulmonary phenomena into mechanical and chymical. Whether death commences by the one or by the other, it is always, as I have proved, the interruption of the last which causes the cessation of life: these then only shall at present occupy my attention.

But before we analyse the effects produced by the cessation of these phenomena upon all the organs, and consequently the mode of action of the black blood upon them, it will not be considered useless, perhaps, to explain the phenomena of the production of this kind of blood at the moment the pulmonary functions are interrupted. This paragraph, which will be somewhat interesting, may belong indifferently to the two preceding articles, or to this.

SECTION I.

An exposition of the phenomena of the production of black blood in the interruption of the chymical functions of the lungs.

It is known in general that the blood is coloured in its passage through the lungs, that from being black it becomes red; but hitherto this interesting subject has been the object of no exact or correct experiments. The lungs of frogs, with large vesicles, and fine and transparent membranes, would be very proper to observe this colouration, if on the one hand the slowness of respiration in these animals, the difference of its mechanism from that of respiration in hot blooded animals, and the very small quan-

tity of blood which passes through the lungs, did preclude our establishing complete analogies between them and the species next to man, or man himself; and if on the other hand the tenuity of their pulmonary vessels, and the impossibility of comparing the changes in the velocity of the circulation, with those of the colour of the blood, did not render incomplete all the experiments made upon these amphibious creatures.

It is in animals with a double ventricle, with a complete pulmonary circulation, a temperature above that of the atmosphere, and with two uncommunicating systems of red and black blood, that we must look for the phenomena of human respiration and of all the functions which depend on it. What precise inductions can be drawn from experiments made upon species in which opposite dispositions are met with?

On the other hand, in all the mammiferous animals whose pulmonary organization resembles that of man, the thickness of the vessels and cavities of the heart prevent us, if not from at all distinguishing the colour of the blood, at least from discovering its particular shades. Experiments made without having this fluid exposed to view, can never therefore afford us strict and perfect ideas.

This has led me to inquire more minutely into what has hitherto been only vaguely determined.

I made use of, what appeared to me, the method of judging correctly of the colour of the blood. It consists, as I have already often mentioned, in adapting, in the first place, to the trachea-arteria laid bare and transversely cut, a cock that may be opened or shut at pleasure, and by means of which, one may suffer the precise quantity of air necessary to the experiments to enter the lungs, introduce and retain there the different gases, pump out all the air contained in the organ, or distend it above the ordinary de-

gree, &c. The animal breathes very well through this cock, when it is open; and will live with it for a considerable time, without any remarkable disturbance in its functions.

In the second place it is necessary to open one of the arteries, the carotid, or crural, &c. for the purpose of observing the different alterations in the colour of the blood which runs from it, according to the quantity and nature of the air which enters into the air-cells.

In general, the small arteries should not be chosen; the blood stops in them too soon. The slightest spasm, or the smallest disturbance of it may suspend its course, while the general circulation continues. On the other hand the large arteries lose in a little time so large a quantity of this fluid, that the animal would soon die from the hemorrhage. But this inconvenience may be remedied, by adapting to these vessels a tube with a very small diameter, or rather by adding to the tube adapted to the artery, a cock which, being opened at pleasure, produces a jet of the desired size.

Every thing being thus prepared upon some animal, of middling stature, upon a dog for example, let us observe what is the series of phenomena presented to us in the colouration of the blood.

In pointing out, in these phenomena, the precise time that the colouration takes up, I shall mention only what I have seen, without presuming that in man the duration of the phenomena is uniform, or that it would be constant in animals examined at the different periods of sleep, digestion, exercise, rest, and the passions, if it were possible to repeat the experiments at these different periods. In general it is to know but little, as I have said, of the animal functions, to expect to subject them to any sort of calculation, because their instability is extreme. The phenomena are the same always, and it is this only which imports us; but their variations, greater or less, are innumerable.

But let us return to our subject, and begin with the phenomena relative to the change of the red blood into black, or rather to the *non-change* of the latter into red.

1st. If the cock is closed immediately after an inspiration, the blood begins, in about thirty seconds, to grow dark; in a minute its colour is deepened; and becomes perfectly like that of venous blood after a minute and a half, or two minutes.

2d. The black colour takes place several seconds sooner, if the cock is closed at the instant the animal expires, particularly if, the expiration having been strong, it has forced out a good deal of air: after a common expiration, the difference is scarcely observable.

3d. If the tube of an injecting syringe is fitted to the cock, and all the air contained in the lungs is pumped out by drawing the piston, whether at once or twice, according to the connexion between the capacity of the syringe and the air vesicles, the blood changes all at once from red to black: twenty or thirty seconds are sufficient for this. It appears that there needs then only sufficient time to evacuate the red blood contained between the lungs and the open artery, and the black succeeds immediately. There is no gradation in it. The shades do not become sucessively deeper during the colouration; it is sudden: because the blood comes out by the arteries, just as it was in the veins.

4th. If, instead of creating a vacuum in the lungs, a quantity of air is thrown in somewhat greater than that which the animal takes in, in the greatest inspiration, and retained there by closing the cock, the blood is longer in attaining its colour; it does not grow dark until after the expiration of a minute; and the stream is not completely black till after three minutes; this varies however according to the state and quantity of the air which is forced in. In general the more there is of this fluid in the lungs, the longer the colouration is in operation.

It follows from all these experiments, that the duration of the colouration of red blood into black, is, generally, in direct ratio to the quantity of air contained in the lungs; that so long as there remains any of the respirable part in the last air vesicles, the blood retains in a greater or less degree the arterial colour; that this colour is weakened in proportion as the respirable part diminishes; and that it remains the same as it is in the veins, when all the vital air has been exhausted at the extremity of the bronchiæ.

I have remarked that in the different experiments in which *asphixia* is produced in an animal, upon closing the cock and thus retaining the air in its breast during the experiment, if this cavity is agitated with violent motions similar to those of inspiration and expiration, the change of colour into black is longer in taking place, or rather that of red continues longer, than if the breast remains motionless: this is probably because the agitation of the air by these violent motions causes it to circulate in the air-cells, and consequently to present its respirable portions under a greater number of points to the blood which must, either unite itself to it, or communicate to it the principles which have become heterogenous to its nature. What I shall soon say on animals, which are made to breathe from bladders, will render this explanation clear.

At present I shall pass on to the change into red of the blood rendered black by the preceding experiments. The phenomena which they were intended to show pass during the interval between *asphixia* and death: these take place during the period between *asphixia* and the return to life.

1st. If the cock is opened after being shut for some minutes, the air immediately penetrates the bronchiæ. The animal forcibly expires what they contain, greedily takes up the fresh, and hastily repeats six or seven large inspirations and expirations. If the open artery is examined

during this time, a very red stream is seen almost at once to succeed to the black it had furnished: the interval is at most not more than thirty seconds. It requires only sufficient time for the black blood contained between the lungs and the opening of the artery to be evacuated; and the red instantly follows. It is the same phenomenon in an inverse ratio, as that pointed out above, on the subject of *asphixia*, by the vacuum made in pumping out the air with a syringe. The successive shades from black to red are not seen in this instance; the change is glaring; the last colour appears even more brilliant than in its ordinary state.

2nd. If, instead of suddenly opening the cock, the air is suffered to enter the trachea-arteria by a very small aperture, the colouration is much less vivid, but equally quick.

3rd. If a syringe charged with air is adapted to the cock, and this fluid is forced towards the lungs, after having opened the cock, and the latter then closed, the blood becomes red, but much less manifestly than when the air enters by voluntary inspiration. This is probably owing to the portion of air injected by the syringe, mixing in the bottom of the cells with that which already exists in the lungs, while on the contrary if the cock is simply opened, expiration first throws out the air which has become useless to the colouration, and inspiration then replaces it with fresh. The following experiment appears to confirm this:

4th. If, instead of forcing in air upon that which is already inclosed in the lungs, the latter is first pumped out, and then fresh injected, the colouration is more rapid and particularly more brilliant than in the preceding case. However it is still somewhat less so than when the air is renewed by natural inspiration and expiration.

5th. The lungs being exposed to view on both sides, by a lateral section of the ribs, the circulation still goes on for a certain time. Then if, by means of the syringe adapted to the cock of the trachea-arteria, the pulmonary vesi-

cles are alternately dilated, and the air expelled that has been forced in, the colours, red and black, are observed by turns, and in a degree nearly equal to that of the preceding experiment, during the time the circulation lasts, and notwithstanding the absence of all mechanical function.

We may, I think, draw from the facts just set forth, the following consequences:

1st. The rapidity with which the blood becomes red when the cock is opened, scarcely permits us to doubt that the principle subservient to this colouration, passes directly from the lungs into the blood, through the membraneous walls of the vesicles, and that a longer passage, such as that of the absorbent system, for example, cannot be traversed by it. I shall very soon farther verify this assertion by other facts.

2nd. The celebrated experiment of Hook, by which the enfeebleed motions of the heart are accelerated in cases of *asphixia*, or in animals with the breast open, by forcing air into the trachea-arteria, may be very well conceived after the colouration previously observed in the same experiment. The red blood, by penetrating the fibres of the heart, relieves the debility with which they had been affected by the contact of the black blood.

3rd. I do not believe that one ever succeeded in resuscitating by this means the motions of the heart, when once they have been annihilated by the contact of the black blood. I have always attempted it in vain, though several authors pretend to have succeeded. This may be easily conceived; in fact, in order that the action of the air should vivify the heart, it is requisite that the blood which it colours should penetrate this organ: but, if the circulation has ceased, how can this happen?

We must however distinguish two cases in the interruption of the action of the heart by *asphixia*. Sometimes

syncope supervenes, and stops the motion of this organ before the influence of the black blood can have produced this effect: then, upon forcing air into the lungs, the latter excited by this fluid, sympathetically arouses the heart, as is the case when an irritating cause is applied, in syncope, to the pituitary, the face, &c. They are the nerves which then form the medium of communication between the lungs and the heart. But when the last has ceased to act, on account of the black blood's having penetrated its texture, then it is no longer susceptible of responding to the sympathetic excitement exercised on it by the lungs, because it contains within itself the cause of its own inactivity, and to surmount this cause, it would require another to act upon it inversely, I mean the contact of red blood; but this contact has become impracticable.

I have endeavoured to ascertain what was the influence of the different gases respired, upon the colouration of the blood. For this purpose I adapted to the tube fixed in the trachea-arteria, different bladders of which some contained *hydrogen*, and others *carbonic acid gas*.

The animal, upon respiring, caused the bladder to swell and fall alternately. At first it rested calm; but at the end of three minutes, the agitation was seen to commence; respiration was hurried and confused: then the blood which flowed from one of the open carotids, became dark, and at last black after four or five minutes.

The difference in the duration and intenseness of the colouration, has always appeared to me very trifling, whichever of the two gases I used for the experiment. This remark should be compared with the experiments of the committee of the Institute, who have observed that *asphixia* does not supervene till after ten minutes, in pure *hydrogen*, and that it takes place at the end of two, in *carbonic acid gas*. The black blood therefore circulates longer in

the arterial system, at the time of the first, than at the time of the second *asphixia*, without killing the animal and consequently without destroying the action of its organs. This confirms some reflections which I shall offer on the difference of *asphixia*.

Why is the colouration more tardy by fitting the bladders to the cock, than by simply closing the latter, without making the animal breathe any gas? this is owing to the air contained in the trachea-arteria and its divisions, at the moment of the experiment, being several times forced into the bladder and back again into the lungs, so that the whole respirable portion which it contains is successively presented to the capillary orifices, which transmit it to the blood.

On the contrary, if the cock is simply closed, the air can with difficulty be agitated with a similar motion; so that when the respirable portion enclosed in the bronchial cellules is exhausted, the blood ceases to be coloured red, though there remains in the trachea and its great divisions a sufficient quantity of this fluid which has not been despoiled of its vivifying principle, as one may be easily satisfied of, even after the entire *asphixia* of the animal, by cutting the trachea below the cock, and immersing a taper therein.

In general it appears that the colouration takes place only at the bronchial extremities, and that the internal surface of the large air-vessels has nothing to do with this phenomenon.

One may be convinced of the truth of the explanation I have offered, by previously pumping the air from the lungs, and then adapting to the cock a bladder filled with one of the two gases, that the animal may respire it unmixed. The colouration is then almost sudden. But in this, as in the preceding experiment, there is but little dif-

ference in the intenseness and rapidity of the colouration, whether the one or the other gas has been employed. I made choice of these two gases because they enter into the phenomena of natural inspiration.

When a bladder is adapted to the trachea-arteria filled with *oxygen*, so that the animal may breathe it nearly in a state of purity, the blood is a long time in acquiring its black colour; but it does not in the first instance assume a redder hue than is natural to it, as I would have suspected.

SECTION II.

The blood left black by the interruption of the chymical phenomena of the lungs, penetrates all the organs, and circulates there for sometime in the vascular system of red blood.

We have just explained the phenomena of the colouration of the blood, in the interruption of the chymical phenomena of the lungs. Before we consider the influence of this colouration upon the death of the organs, we shall first prove that all are penetrated by the blood left black.

I have demonstrated that the power of the heart existed for sometime in a degree equal to what is natural to it, though the black blood enters it; that this blood at first flows out with a jet equal to that of the red; and that the diminution of this jet is gradual and consecutive, &c. I might already conclude from this, 1st, that the arterial circulation still continues for a certain time, though the arteries contain a fluid different from that to which they are accustomed; and 2ndly, that the necessary effect of this prolonged circulation, is to penetrate with black blood

all the organs which were accustomed only to the contact of the red. But we shall deduce this conclusion from correct and accurate experiments.

To estimate correctly this important fact, it is sufficient to expose to view the different organs successively, while the tube adapted to the trachea is closed, and the animal consequently in a state of *asphixia.* I have thus examined by turns the muscles, nerves, membranes, viscera, &c. This is the result of my observations:

1st. The colouring matter of the muscles is found in two different states: it is either free or combined; free in the vessels where it circulates with the blood to which it belongs; and combined with the fibres, and then out of the circulatory passages; it is the last part which particularly forms the colour of the muscle. But it experiences no alteration in *asphixia;* it remains constantly the same; on the contrary, the other blackens perceptibly. When cut through, the organ furnishes a great number of small blackish drops which are indications of the divided vessels, and which spring from the natural red of the muscles: it is the blood circulating in the arterial system of these organs, to which it gives the livid taint they then present, and which is very observable in the heart where more ramifications meet together than in the other muscles.

2nd. The nerves are naturally penetrated by an infinite number of small arteries which creep through their texture, and which convey to them excitement and life. In *asphixia* the black blood which pervades them is observable by a dark brown colour which is seen to succeed to the rosy white natural to these organs.

3rd. There are few parts where the contact of the black blood is more visible than in the skin: the livid spots so frequent in *asphixia*, are, as we have said, only the effect of the obstacle it experiences in passing into the general

capillary system, whose organic insensible contractibility is not sufficiently excited by it. To this cause also are owing the turgidity and tumefaction of certain parts, as the cheeks, lips, the face in general, the skin of the cranium, and sometimes that of the neck, &c. This phenomenon is the same as that presented by the lungs, which not being in a situation to admit the passage of the blood, in the last moments, become the seat of an *engorgement* which particularly affects the capillary system. Besides, this phenomenon is infinitely more marked there than in the general capillary system, for the reasons explained above.

4th. The mucous membranes also afford a similar phenomenon, when the chymical functions of the lungs are interrupted. The tumefaction so frequent in the tongue, of persons drowned, or hanged, or in cases of *asphixia*, from the vapour of charcoal, &c. the lividity of the membrane of the mouth, bronchiæ, intestines, &c. taken notice of by most authors, depend upon the same principles. Of this the following is in proof:

Take out a portion of the intestine of an animal; rip it open so as to display its internal surface; and close the cock previously adapted to the trachea-arteria; in about four or five minutes, or sometimes later, a dark brown hue succeeds to the red which characterizes this surface in its natural state.

5th. I have made the same observation upon the fleshy granulations of a wound made in an animal for the purpose of remarking in it this colouration by the black blood. We must observe however that in the two preceding experiments, this phenomenon is slower in taking place than in many other circumstances.

6th. The colouration of the serous membranes, by the means I have pointed out, is much more prompt, as may

be readily proved, by comparatively examining the internal and external surfaces of the intestine, while the cock is shut: the reason of this is, that in these kinds of membranes, the livid hue which they assume depends not upon the blood which penetrates them, but upon the vessels which creep underneath them; such as the arteries of the mesentery under the peritoneum, those of the lungs under the pleura, &c. Now these vessels being considerable, it is the great circulation which is carried on in them, and by which consequently the black blood enters them, almost the instant it is produced. In the mucous membranes, on the contrary, as well as in *cicatrices*, it is by the capillary system of the membrane itself, that the colouration takes place. This system is much slower in receiving the black blood, and in being penetrated by it, than the first; and sometimes it even refuses to admit it in certain parts: thus I have several times seen the membrane of the *fossæ nasales* very red in animals killed by *asphixia*, while that of the mouth was livid, &c.

In general the black blood is carried into the general capillary system in three ways: 1st, there are places where it does not penetrate at all, and then the parts retain their natural colour; 2nd, there are others into which it manifestly passes, but where its course is arrested, and thus if but little has entered, a simple colouration is observed, and if much, a tumefaction of the part added to the colouration; and lastly, in other cases the black blood travels through the capillary system without stopping, and passes into the veins, as the red blood did.

In the first and second cases the general circulation meets with the opposing obstacle in the general capillary system; in the third, which is much more general, it is in the capillaries of the lungs that the course of the blood is suspended after having circulated in the veins.

These two obstacles very often coincide with each other. Thus, in *asphixia*, a part of the black blood circulating in the arteries, is stopped in the face, in the mucous surfaces, tongue, lips, &c.; the other part, much the most considerable, which has met with no obstacle in the general capillary system, goes on to engorge the lungs, and there meets with the term of its motion.

Why do certain parts of the general capillary system refuse to admit the black blood, or, if they do admit it, why can they not force it on into the veins, while other parts, less easily debilitated by the influence of its contact, favour its circulation as usual? Why is the first phenomenon more particularly observable in the face? This can depend only on the connexion there is between the sensibility of each part and this kind of blood: but this connexion is unknown to us.

I was willing to avail myself of the facility with which the colour of the blood may be varied, according to the state of the lungs, to distinguish the influence of the circulation of the mother upon that of the infant. To this end I procured a pregnant bitch; and produced *asphixia* in her by closing a tube adapted to her trachea-arteria. Four minutes after all communication had been intercepted between the external air and her lungs, she was opened; the circulation continued: an incision was made into the matrix as well as its membranes, and the cord of two or three of the *pups* was laid bare. We could perceive no difference between the blood of the vein and the umbilical arteries: it was equally black in both kinds of vessels.

I was not able to procure other pregnant bitches of sufficient size to repeat this experiment after another manner. It was wanting in fact, 1st, to lay bare the cord, and compare in the first place the natural colour of the blood of the artery with that of the umbilical vein. Their difference.

in the fœtuses of several guinea-pigs, appeared to me infinitely less than it is in the adult; in the two vascular systems, and in several circumstances it is reduced to nothing. The two kinds of blood are equally black, notwithstanding the respiration of the mother is carried on very well, after the opening of the belly. 2d, To close the cock in the trachea, and to observe if the changes in the colouration of the blood of the umbilical artery of the fœtus (supposing its blood to be different from that of the vein) corresponded with those which must then be inevitably going on in the arterial system of the mother, or if the one had no influence on the others. Experiments made with this view upon large animals, might greatly elucidate the mode of vital communication between the mother and the fœtus. Observations on the colour of the blood in the human fœtus, and on the cause of its change from livid into deep red, sometime after its leaving the uterus, are also much to be desired.

I could add various examples to those I have just set forth, on the colouration of the different organs, by the black blood. Thus, the kidney of a dog, opened during the presence of *asphixia*, discovers a much more remarkable lividity than during his life, in the cortical substance, where the arteries are particularly distributed, as is known. And thus also the spleen or the liver, when cut through, yield nothing but black blood, instead of that mixture of black and red drops which is observed when these organs are divided in the living animal, when the respiration is free, &c.

But, I trust, we have a sufficient number of facts to establish with certainty, that the blood left black, after the interruption of the chymical phenomena of the lungs, still circulates for some time, penetrates all the organs, and takes the place in them of the red blood which had moistened their texture.

This consequence leads us to the explanation of a phenomenon which has no doubt drawn the attention of all who

have been in the habit of opening dead bodies, namely, that no other than black blood is ever met with in them, even in the vessels appropriated to the red.

In the last moments of existence, whatever may be the kind of death, we see that the lungs are almost always obstructed and their functions finished, before those of the heart are interrupted. The blood continues to circulate several rounds, after it has ceased to receive the influence of the air: it circulates *black* then for a certain time, and for the same reason remains so in all the organs, though however the circulation is much less distinct than in *asphixia*, and this it is which constitutes the great differences of this kind of death, of which we shall hereafter speak. Nothing can be more easy, after this, than to conceive the following phenomena:

1st. When the ventricle and auricle of red blood, the curve of the aorta, &c. &c. contain blood, it is always black, as is well known to those in the frequent habit of injecting. In exercising my pupils in the practice of chirugical operations, I have always observed that when the open arteries were not entirely empty, and that a little blood still oozed out, it was constantly of the same colour.

2d. The *corpus cavernosum* is always gorged with this species of fluid, whether it be in its natural state of flaccidity, or remain in erection, as I have seen it in two subjects brought to my amphitheatre; the one had been hanged, and the other had experienced some violent commotion, under which he appeared to have suddenly sunk.

3d. The blood which more or less distends the spleen of dead bodies, is scarcely ever found red; however, the exterior of this organ, and its concave surface, sometimes present spots of a lively scarlet colour, which I know not well how to account for.

4th. The mucous membranes lose, after death, that redness which characterised them during life; and they almost always assume a dark, sombre hue, &c.

5th. If the blood which is effused in the brain of apoplectic patients is examined, it is almost constantly found black.

6th. Frequently, instead of being carried inwardly, the blood has an external direction. The whole face, neck, and sometimes the shoulders, are then swelled and suffused with blood: it is common enough to meet with this disposition in dead bodies, but I have never seen it coincident with an internal effusion. If the skin is examined in these cases, it is always found of a violet or deep brown colour, a manifest indication of the species of blood effused in it. It is not, as has been said in accounting for this colour, the reflux of venous blood which produces the phenomenon, but the stagnation of the black blood which, at the moment of death, is circulating in the external capillary system, where it meets with an obstacle, and which it choaks up instead of breaking through, and percolating through their coats, as happens in the brain. I presume that this difference arises from the greater resistance, and more serried texture of the external than of the internal vessels.

I shall not extend farther the numerous consequences of the principle established above, namely, of the circulation of the black blood in the arterial system during the last moments which terminate life; I shall only observe that when death commences by the circulation, as in wounds of the heart, &c. the preceding phenomena are not observed, or are at least not so clearly perceptible.

We come now to the examination of the influence which the lungs exercise on the organs whose texture is penetrated by it.

SECTION III.

The black blood is not proper to support the activity and life of the organs, which it penetrates the moment the chymical functions of the lungs have ceased.

What is the influence of the black blood carried to the organs by the arteries? To resolve this question, we must remark that the first effect of the contact of the red blood is to excite these organs, to stimulate, and keep up their life, as the following observations prove:

1st. Compare inflammatory tumours, *erysipelas*, *phlegmon*, &c. to the formation of which the red blood essentially concurs, with scorbutic blotches, *petechiæ*, &c. &c. which are produced more particularly by the black blood; and you will find the one characterised by the exaltation, and the others by the local prostration of the powers of life.

2d. Observe accurately two men, the one with a red face, large chest, and a cutaneous surface, susceptible of being strongly flushed by the slightest exercise, &c. announcing the plenitude of the development of those functions which change the black blood into red, and the other whose pale and livid hue, contracted, narrow chest, &c. give external indications that these functions languish: examine these two men, I say, and you will see what difference there is in the energy of their respective powers.

3d. The *gangrænæ seniles* for the most part commence by a lividity in the part, which is an evident indication of the absence, or diminution of the red blood.

4th. The redness of the gills, in fish, is a mark by which their vigour is known.

5th. The redder granulations are, the better is their nature: the more pale or brown they are, the less is the wound disposed to heal.

6th. The flushings of the whole head, of the face more particularly, the fiery appearance of the eyes, &c. are always coincident with the energetic action of the brain, in certain febrile paroxysms.

7th. The better developed the pulmonary system in animals, the more active is the colouration of the blood in them, and consequently the more perfect and more developed is the animal life of their different organs.

8th. In youth, which is the age of vigour, the red blood predominates in the animal economy. Who does not know that in old persons the arteries are proportionally more contracted, and the veins larger than in the first years of life? and who does not know that the connexion of the vascular systems, is inversed in the two extreme ages of life.

I am ignorant how the red blood excites and keeps up, by its nature, the life of all the parts. Perhaps it is by the combination of its colouring principles, with the different organs to which it comes. The difference of the phenomena offered by the general and pulmonary capillary systems, is as follows:

In the first, the blood, upon changing its colour, leaves in the parts the principles which render it red; whereas in the second, the elements to which it owes its blackness are rejected by expiration and the accompanying exhalation. Does not this union of the colouring principles of arterial blood, with the different organs, enter considerably into the cause of that constant excitement by which they are kept in force, and which is necessary to their action? If this be true it may be readily conceived, that the black blood not having the materials of this union to communicate, cannot act as a stimulus to our different parts.

I merely offer this idea, however, without resting on it in any manner; it may be ascribed to the sedative action, which I have said was perhaps exercised on the nerves by the black blood. However probable an opinion may appear, which will not admit of demonstration by rigorous experiment, no importance should be attached to it by judicious minds.

Let us endeavour to find out then, abstracted from all system, how the contact of the black blood upon the parts produces their death.

We may here, as we have done in speaking of the death of the heart, divide the parts into those which belong to animal life, and those which concur to the production of organic phenomena. Let us see how they both cease to act.

All the organs of animal life are under the dependance of the brain; if the phenomena of this organ are interrupted; theirs must necessarily cease. We have seen that the contact of black blood strikes the cerebral functions almost suddenly with atony. Under this first consideration, the locomotive, vocal and sensitive organs, must therefore remain in inaction in persons labouring under *asphixia;* it is the only cause which suspends their exercise in the various experiments in which black blood is forced into the brain, while the other parts receive none of it. But when this fluid circulates in the whole system, when all the organs, like it, are subjected to its influence two other causes are joined with this:

1st. The nerves which are found penetrated with it, are no longer susceptible of establishing communications between the brain and the senses on the one hand, and on the other hand between this and the locomotive and vocal organs;

2nd. The contact of the black blood upon these organs themselves, destroys their action. Inject this kind of blood

taken from one of the veins, into the crural artery of an animal; you will find its motions very sensibly weakened, and that sometimes a temporary paralysis supervenes. In this experiment, I observe that the fluid should be injected in the uppermost part of the artery, and thrown in abundantly. If the vessel is opened in its middle, the muscles of the thigh receiving almost all the red blood, will continue their different motions, without any alteration. This has occurred to me in two or three instances.

I am aware that it may be said that the ligature which it is necessary to make on the artery in this experiment, is the only cause of *paralysis* in the limb. Indeed it has twice happened that the motions were, if not entirely destroyed, at least considerably diminished, by this means; but I have often remarked also that it had scarcely any influence, no doubt because the capillaries then supplied the deficiency, which cannot happen in the known experiment of Stenon, in which the ligature is applied on the aorta, and in which the motion is always immediately intercepted. However the result of the injection of black blood is almost constantly as I have stated it; I say almost, for 1st, I have seen it fail once, though with all the requisite precautions; and 2d, the enervation of the motions varies, according to the animals made use of, both in its duration and degree.

There is also in this experiment a manifest suspension of feeling, which is sometimes slower in taking place than that of the motion, but which always happens, particularly if the injection of black blood is repeated three or four times, at trifling intervals.

A similar effect, but more slowly and with more difficulty, is produced by fitting to the canula placed in the crural, a tube communicating with the carotid of another animal whose trachea-arteria is closed, in such a manner that the heart of the latter may force on the black blood into the thigh of the former.

The organs of internal life, independent of the cerebral action, are not interrupted, like those of external life, by the suspension of this action, when the black blood circulates in the arterial system; the simple contact of this blood is the cause which suspends their functions. The death of these organs has therefore a principle less than that of the organs of locomotion, voice, &c.

I have already demonstrated the influence of black blood upon the organs of circulation; we have seen how the heart ceases to act when penetrated with it; it is also in part because this fluid is spread through the arterial and venous coats by the small vessels which concur to their structure, that their functions are debilitated and cease.

It will no doubt always be difficult to prove in a rigorous manner, that the secretions, exhalation, and nutrition cannot imbibe from the black blood the appropriate materials to maintain them; for this species of blood does not circulate long enough in the arteries, to admit of experiments being made upon these functions.

I have notwithstanding made some attempts towards it: to this end I, 1st, laid open the internal surface of the bladder of a living animal, after having cut the symphisis, and opened the lower belly; I next examined the oozing of the urine through the orifice of the ureters, while I produced *asphixia* in the animal by closing the cock fixed in the trachea-arteria; 2d, I cut the *vasa deferentia*, first laid bare, to see if, during *asphixia*, the semen would drop, &c. &c.

I have in general remarked that during the circulation of black blood in the arteries, no fluid appeared to flow from the different secretory organs. But I confess that in all these experiments, and others similar which I have also attempted, the animal experiences too great a degree of distress, both from the *asphixia* and the large incisions it is made to undergo; and the time the experiment lasts

is too short, to admit of inferences being drawn sufficiently unequivocal to be methodically adopted.

It is therefore chiefly from the analogy of what happens to the other organs, that I conclude that those of secretion, exhalation and nutrition cease their functions upon the ingress of black blood.

This accords besides very well with various phenomena of *asphixia:* 1st, thus the defect of cutaneous exhalation during the sufficient length of time that the black blood circulates in the arteries before death, is perhaps one of the causes of the continuance of animal heat in subjects attacked with this accident; 2d, I have constantly observed that in dogs slowly killed, during digestion, by gradually depriving them of air, the *choledocus*, hepatic duct, and duodenum contain much less bile than they usually do at this period when laid open in a living animal; and thus. 3dly, as I have said, the blood losing nothing by the different functions mentioned above, accumulates in large quantity in its vessels. This also is the reason why it is so very fatiguing to dissect the bodies of persons hanged, or suffocated by charcoal, &c. The fluidity and abundance of their blood is troublesome and embarrassing. This abundance, which has been observed by various authors, may depend also upon the debilitated absorbents not taking up the serous portion of the blood contained in the arteries, after death by *asphixia*, as is the case in almost all dead bodies where this portion separates from the coagulum which remains in the vessel: here there is neither separation nor absorption.

The excretions also appear then not to be carried on because of the debility produced in the excretory organ, by the contact of black blood; thus the bladder has been frequently observed to be very much distended in persons who have died of *asphixia*, as M. Portal remarks. It has

not had the power to evacuate the urine contained in it previous to the accident, though life still remained for some time. In general those cases of asphixia produced by black blood alone and without any deleterious agent, are not accompanied with those contractions so frequent at the moment of, or some few minutes after most other deaths, in the rectum, bladder, &c. which produce the almost total evacuation of the respective fluids of these organs, and which should be distinguished from the simple relaxation of the *sphincters*, from which similar effects result. Symptoms of general debility are always present; that increase of life, and that development of powers which so often mark the last hours of the moribund, are never observed.

This accounts, perhaps, for the great suppleness of the limbs, observed in persons who have died of *asphixia*. The stiffness of the muscles appears, indeed, to depend upon this circumstance, that, death seizing them at the moment of contraction, their fibres remain coherent and close together. In those cases of which we speak, on the contrary, a general relaxation, and a universal defect of action, existing in the parts when life abandons them, they remain in this state, and yield to impulsions communicated to them.

I confess, however, that this explanation leaves one difficulty, to which I cannot offer a solution; persons suffocated by mephitic vapours, perish nearly in the same manner as if drowned; or at least, if the cause of death is different, the black blood for a considerable time equally circulates in the arteries. This may be seen by opening the carotid of two dogs at the same time that one has been killed by the vapour of charcoal forced into the lungs, and the other by injecting into the same organ a certain quantity of water and keeping it there by closing the cock of the tube adapted to the trachea-arteria, and which is very soon converted into froth, as in drowned animals.

Notwithstanding this analogy in the last phenomena of life, the limbs remain flexible and warm for a certain time in the first; and they become stiff and cold in the second, particularly if the body is plunged into water during the experiment (for I have observed that the loss of heat is less speedy, if the animal is drowned by injecting water, than if he is plunged into it altogether). But let us return to our subject.

We may conclude, I think, with confidence, from all the facts and considerations contained in this article, 1st, that when the chymical functions of the lungs are interrupted, all the organs simultaneously cease their functions by the effect of the contact of black blood, whatever may be the *modus operandi* of this blood; 2d, that their death coincides with that of the brain and heart, but does not immediately result from them; 3d, that if it were possible for these two organs to receive red blood while the others were penetrated with the black, the former would continue the exercise of their functions, while those of the latter would cease; and *lastly*, that asphixia is a general phenomenon which takes place at the same time in all the organs, and which is not *particularly* developed in any *one*.

From this manner of regarding the influence of black blood upon the parts, it appears that death very soon results from its finding its way into the arteries. Nevertheless certain organic defects have sometimes prolonged till after birth the mixture of the two sorts of blood, which, as is known, prevails in the fœtus: such for example, as that malconformation of the aorta arising by a branch from each ventricle, in the child of which Sandifert has made mention; and such as, at first sight, the opening of the *foramen ovale* appears to be in the adult.

We must remark, however, that the existence of this *hole* does not always suppose the passage of black blood in-

to the auricle of red blood, as has been generally believed. In fact, the two semilunar valves between which it is situated, when it is met with after birth, are necessarily applied one against the other, by the pressure of blood contained in the auricle against them, at the time of the simultaneous contraction of these cavities. The *hole* is then shut, and its obliteration is much more perfect than that of the opening of the ventricles by the *valvulæ mitrales* and *tricuspides*, or than that of the aorta and pulmonary artery by the *sygmoid* valves.

It is very common, moreover, to meet with this hole open in dead bodies; I have already seen it several times. When it does not exist, there is nothing more easy than to destroy the generally very feeble adherence of the two valves which close it, by slipping the point of a scalpel between them. If the opening thus made is examined, it will be found that there is often no solution of continuity produced, but a simple disunion.

The *hole*, thus artificially opened, presents the same disposition as is found naturally in some dead bodies. Now if this disposition is examined, it will be seen that when the auricles contract, the blood necessarily forms an obstacle to itself, and cannot pass from one to the other. One may easily be satisfied also of the reality of the mechanism of which I speak, by making two injections at the same time of different coloured fluids into the two sides of the heart, through the *venæ cavæ* and pulmonaries.

After all that we have said, as well of the influence exercised by the blood on the different organs whether by the motion with which it is agitated or by the different principles which compose it, as of the death which succeeds in the organs to the annihilation of these two modes of influence, it is evident that the white organs, which are not in a natural state penetrated by the blood and which conse-

quently the heart does not hold under its immediate dependance, must cease to exist in a different manner from those which are directly subject to its control. Asphixia cannot all at once reach them; they do not, like the others, suddenly cease their functions, in wounds of the heart, *syncope*, &c. In short, their life being different their death cannot be the same. But I cannot attempt to determine how their death arrives; for I am not sufficiently acquainted with the life which precedes it. No correct demonstration has yet appeared to me of the mode of circulation in those organs, of the fluids which penetrate them, or of their nutritive connexions with those to which the blood has ingress, &c. &c.

ARTICLE IX.

OF THE INFLUENCE OF THE DEATH OF THE LUNGS ON GENERAL DEATH.

UPON summing up what has been said in the preceding articles, on the influence of the lungs upon the heart, brain, and all the organs, it is easy to form an idea of the successive termination of all the functions, when the phenomena of respiration are interrupted, as well in their mechanical as in their chymical portion.

The following is the way in which death is brought on if the mechanical phenomena of the lungs cease, whether by the various causes set forth in Article V, or by others similar, as by a rupture of the diaphragm proceeding from a fall on the abdomen, the viscera of which pressed up-

wards, as I have already had occasion twice to observe,* by the simultaneous fracture of a great number of points, by the depression of the sternum, &c. &c.

1st. There are no more mechanical phenomena; 2d, the chymical phenomena cease for want of air to support them; 3d, the cerebral action ceases, for want of red blood to excite the brain; 4th, there is a cessation of animal life, sensation, locomotion and voice, for want of excitement in the organs of these functions, by the cerebral action and by the red blood; 5th, the general circulation stops; 6th, the capillary circulation ceases, and the secretions, absorption and exhalation, through defect of action exercised by the red blood upon the organs of these functions; and 7th, digestion ceases through defect of secretion and excitement of the digestive organs, &c. &c.

The phenomena of death succeed each other in a differferent manner, when the chymical functions of the lungs are interrupted; 1st, in the exhausted receiver of an air-pump; 2d, at the moment of an obliteration of the trachea-arteria, by a cock artificially adapted to this canal, by an extraneous body gaining entrance into it, by strangulation, by a polypus, or by mucous collections in the air-cells, &c.;

* When the diaphragm is broken, a sudden cessation of the functions is not always the result of this accident. There are instances of many cases where the patients have survived their fall for several days; and where the cause of death could not be ascertained until after the body was opened.

The intercostal muscles are, in this case, the only agents of respiration, which is carried on nearly like that of birds, or of animals with red and cold blood, which are not possessed of this intermediate septum between the thorax and abdomen.

Lieutaud relates several cases of ruptures of the diaphragm, produced by other causes than external injuries. Diemerbroek has mentioned an instance where this muscle was wanting in a child that lived notwithstanding for seven years.

3d, in the various inflammatory schirrous and other affections of the mouth, throat, larynx, &c.; 4th, in submersion; 5th, during a sojourn on the top of very high mountains; 6th, in the accidental introduction of the different non-respirable gases, such as *carbonic-acid gas*, *azote*, *hydrogen*, *oxygenated-muriatic gas*, *ammoniac*, &c.; and 7th, during a protracted respiration in common air, *oxygen*, &c. &c. In all these cases death supervenes in the following manner.

1st. The interruption of chymical phenomena; 2d, the *necessarily* subsequent suspension of cerebral action; 3d, a cessation of the sensations, voluntary locomotion, and hence also of the voice and mechanical phenomena of respiration, phenomena in which the motions are the same as those of voluntary locomotion; 4th, an annihilation of the action of the heart, and of general circulation; 5th, a termination of the capillary circulation, of the secretions, absorption, and consequently of digestion; and 6th, a cessation of animal heat which is the result of all the functions, and which does not abandon the body so long as any of them remain in activity. By whatever function death may commence, this is always the last to feel its approach.

SECTION I.

Remarks on the differences presented by the different species of asphixia.

Though in the double kind of death of which I have just explained the successive concatenation of phenomena, the black blood always has a special influence, by its contact, on the enervation and interruption of the action of the organs, it must nevertheless not be supposed that this is

constantly the sole cause. If this was the case, every case of *asphixia* would present a similar phenomena, as the following considerations prove:

On the one hand, there is in all these affections an interruption in the colouration of the blood, and consequently a circulation of black blood in the arterial system; on the other hand, the blood does not present different shades peculiar to each species of *asphixia;* it is the same in all, that is to say, it passes into the vascular system of red blood, exactly as it was in the other. I have had frequent opportunities of convincing myself of this fact. In whatever mode I attempted to produce a cessation of the chymical phenomena of the lungs, in my experiments, the blackness of the blood appeared nearly uniform.

Notwithstanding this uniformity relative to the phenomena of the colouration of the blood in cases of *asphixia*, there is nothing more variable than their symptoms and the progress of the appearances they occasion. Their differences relate, sometimes to the duration of the operation of death, sometimes to phenomena which take place in the last moments, and sometimes to the state of the organs, and the sum of the powers they retain after life has abandoned them, &c.

1st. *Asphixia* varies as to its duration: it is quick in *sulphurated-hydrogenous*, and *nitrous gas*, and in certain vapours arising from privies, &c.; it is more gradual in *carbonic-acid gas*, in *azote*, in air exhausted by respiration, in pure *hydrogen*, in water, *in vacuo*, &c.

2d. It varies as it respects the accompanying phenomena: sometimes the animal is violently agitated, is seized with sudden convulsions, and his life is terminated in extreme agitation; sometimes his powers appear to escape him in a tranquil manner, to pass first from life to sleep, and then from sleep to death. If the numerous effects

arising from privies, of the vapours of charcoal, of the different gases, of submersion, &c. on the animal economy are compared, it will be found that each of them operates in a very different and often contrary manner.

3d. The phenomena which *succeed* asphixia are also very variable. Compare the coldness of the body of a drowned person, to the long-continued heat of one suffocated by the vapour of charcoal; read the result of the various experiments mentioned in the Report of the Committee of the Institute, upon the influence which *galvanism* receives from different species of *asphixia;* examine the detail of symptoms which accompany the *mephitis* arising from privies, which are to be found in a work of M. Hallé, who particularly concurs with the Report just spoken of; collect the numerous observations scattered through the works of various other physicians, of M. Portal, Louis, Haller, Troja, Pechlin, Bartholin, Morgagni, &c. &c.; make the most common experiments, and such as are most easy to repeat on submersion, strangulation, and suffocation by the different gases: you will find very remarkable differences in all these species of *asphixia;* you will observe that each one is almost *characterised* by a different state in the bodies of the animals that have been exposed to them.

To come to the cause of these differences, we must in the first place divide *asphixia* into two classes: 1st, into those which supervene by the simple defect of respirable air; 2d, into those in which, to the former cause is added the introduction of some deleterious fluid into the lungs.

When the simple defect of respirable air occasions *asphixia*, as in those produced *in vacuo*, by strangulation, by remaining too long in air which cannot be renewed, &c. or by some extraneous body in the trachea-arteria, &c. &c.; then the immediate cause of death appears to me to be only the contact of black blood upon all the parts, as I have explained at large in the course of this work.

The general effect of this contact is always the same, whatever may be the accident which produces it; therefore the concomitant symptoms and the secondary results of all these kinds of death in general produce but little difference. Their duration is the same; if it varies it proceeds only from the more or less speedy interruption of the air which is sometimes suddenly withdrawn, as in strangulation, and sometimes only partly intercepted, as when extraneous bodies partially cover the *glottis*.

This variety in the duration and intenseness of the cause creating *asphixia*, may produce the like in some of the symptoms; as for example, the greater or less lividity and swelling of the face, the more or less considerable embarrassment of the lungs, &c. the more or less powerful disturbance in the functions of animal life, the greater or less irregularties of the pulse, &c. But all these differences do not indicate a diversity of nature in the cause which interrupts the chymical phenomena; they do but point out the different modifications of the same cause. Hence, for example, 1st, a person hanged does not die in the same manner as one suffocated by an inflammatory tumour, or as one into whose trachea-arteria some extraneous body has found admittance, &c.; 2d, if an animal is caused to perish under a bell filled with atmospheric air, he will remain a much longer time free from *asphixia* than if the trachea-arteria is artificially closed, and a much shorter time than if the bell contained *oxygen;* 3d, the symptoms of *asphixia*, at a height of the atmosphere where the air is too much rarified does not afford sufficient aliment to life, and in an intense heat which produces the same effect upon this fluid, differ very much in appearance from *asphixia* occasioned by the sudden opening of the thorax, by violent compression of this cavity, and in a word by all the causes which begin their operation by the mechanical phenomena.

In all these cases, there is but one principle of death, namely, the absence of red blood in the arterial system; but according as the black blood passes immediately into this system, such as it was in the veins, or as it still imbibes something in the lungs, the phenomena which take place during the last moments, and also after death, vary in a singular manner. I say after death, for I have constantly observed that in every case of *asphixia* produced by the simple defect of respirable air, the slower life is in terminating, and the longer consequently the state of anguish and uneasiness is protracted by the small quantity of air still received in the lungs, the less forcibly are the irritability and galvanic susceptibility displayed in the consecutive experiments.

But if the introduction of a foreign aeriform fluid into the bronchiæ, is added to the defect of respirable air, then the variety of symptoms no longer depend on the various modifications of the cause producing *asphixia*, but upon the difference of its nature.

This cause is indeed twofold in the case under present consideration. 1st, The blood remaining bl. ck for want of its colouring elements, and carried into all the organs through the arterial system, as in the preceding case, equally produces the debility and death of these organs, or rather it cannot maintain their action. 2d, The pernicious principles introduced into the lungs with the *gas* to which they are united, act directly upon the powers of life, and cause their prostration and annihilation. There is therefore an absence of the proper stimulus to keep up the vital energy, and the presence of a deleterious matter to destroy it.

I observe however that all *gases* do not act in this manner: it appears that many of them cause the destruction of animals only because they are not respirable, and because they do not contain the colouring principles of the blood. Such, for example, is pure *hydrogen*, in which *asphixia*

operates nearly in the same manner as when the trachea-arteria is simply obliterated, or as when the air of respiration has been all exhausted, &c. and in which, as the Committee of the Institute observe, it is much slower in being effected than in the other aeriform fluids.

But when, by exhalations arising into the atmosphere, from a privy, from a cavern, or from a sink where putrid matters are collected, a man at the moment of his breathing them is seized with *asphixia*, and with convulsive motions, violent agitations, &c. then there is certainly something more than the interruption of chymical phenomena, and consequently than the non-colouration of the black blood.

Indeed, 1st, there still enters into the lungs a sufficient quantity of respirable air, the vehicle of the *mephitic* vapours, to keep up life and its different functions for a certain time; 2d, supposing that the quantity of *mephitic* vapours was so great as to leave no room for respirable air, death would happen only gradually, and without sudden and violent starts and convulsions; it would, in short, be such as is produced by the simple privation of this air: now the totally different manner in which it supervenes, proves that in this case, besides the contact of black blood, there is an action of some deleterious substance in the animal economy.

These two causes act therefore simultaneously in *asphixia* by the different *gases*. Sometimes one predominates; and sometimes their action is equal. If the deleterious quality is considerable, it often kills the animal before the black blood can have produced much effect; if it is not so, life is extinguished as much by the influence of the latter as of the former; if the *mephitis* is feeble, it is principally the black blood which produces death.

Asphixia by the gases or *mephitic* vapours are all alike, therefore, as to the debility produced in the organs by the black blood; in this respect they are likewise similar to

those occasioned by the simple privation of respirable air. They differ as to the nature of the *mephitis;* and this nature varies infinitely; it is supposed to be known in some aeriform fluids, but in the greater number we are yet almost entirely ignorant of it; it is more particularly unknown to us in the vapours arising from fæcal matter long retained, from common sewers, &c.

From this consideration I shall avoid speaking of the special nature of the different kinds of *mephitis*, and of the variety of symptoms which may arise from the action of each in particular; and attend only to the effects that result from this action considered generally.

I may remark also that the variety of these effects may depend in a great measure upon the state in which the individual may be, so that the same poison will produce different symptoms according to temperament, age, the disposition of the lungs, brain, &c. But in general these varieties exist oftener in the intenseness, force, or weakness of the symptoms, than in their nature, which is pretty constantly the same.

How do the different deleterious substances which are introduced into the lungs with the mephitic vapours of which they form a part, act upon the animal economy? This can be in two ways only; 1st, by affecting the nerves of the lungs, which react then sympathetically on the brain; or, 2d, by passing into the blood, and thus by means of the circulation exciting their influence directly upon this organ, and in general, upon all the rest.

I believe that the simple action of a deleterious substance upon the nerves of the lungs, may have a considerable effect in the economy, that it is capable also of disturbing the functions in a very sensible manner; very nearly after the same manner as an odour, by touching the pituitary, acts sympathetically on the heart, and produces syncope, as the sight of a hideous object produces the same effect,

as an irritating enema rouses all at once for a moment the powers of life, as the vapour of vinegar, or the juice of an onion, directed upon the *membrana conjunctiva* during syncope, is sometimes sufficient to arouse all the organs, and as the introduction of certain substances into the stomach produces a sudden revolution in the whole economy before these substances have had time to pass into the circulatory current, &c.

Instances in which the simple contact of a body upon the mucous surfaces, produces a sympathetic reaction upon the different organs all at once, and occasions very remarkable phenomena throughout the whole body, are met with every day.

We cannot, therefore, reject this mode of action of the deleterious substances that are introduced into the lungs. But the same reason that induces us to admit it in many cases, will direct us at the same time not to exaggerate its influence.

I do not know, indeed, a single example where the simple contact of a deleterious body upon a mucous surface, suddenly produced death. It may bring it on after a certain time, but never occasion it at the instant of its action.

Notwithstanding, in *asphixia* from *mephitic* vapours, such is often the rapidity with which death supervenes, that the black blood can scarce have had time to exert its influence, and the principal cause of the cessation of the functions is very manifestly the action of the deleterious substances.

This circumstance would lead us then to believe that these substances pass into the blood through the lungs, and that, circulating with this fluid, they carry to all the organs, and principally to the brain, the immediate cause of their death. Many physicians have already suspected and even admitted this passage into the blood of the deleterious matters introduced by the respiration of mephitic vapours, but

hitherto without much proof. The following numerous considerations appear to me to establish it beyond a doubt:

1st. It cannot be doubted, I presume, that the poison of the viper, and of other venomous reptiles, as well as of *rabid* animals, is introduced into the sanguiferous system, whether by the veins, or by the lymphatics, and that it is only by its circulation with the blood that it produces those fatal effects which result from it. Why should not effects still more fatal and sudden be produced in the same manner in asphixia from *mephitic* vapours?

2d. It appears very certain that a portion of the air which is breathed, passes into the blood, and that, by combining with it, it produces its colouration. This passage is made through the mucous membrane itself, and not by the absorbent system, as has been proved, in my experiments, by the promptitude of the colouration. Now, what is there to prevent the *mephitic* vapours from following the same course as the respirable portion of the air? I know that the proper sensibility of the lungs may create a sort of affinity for this respirable portion, and not for the vapours; and that they may therefore admit the former and reject the latter. It is for this reason, no doubt, that in the natural state, none of the principles constituting atmospheric air, except the vital part, are permitted to traverse the lungs and mix with the blood. But, are we acquainted with the precise limits of this affinity or connexion of the sensibility of the lungs, with every substance? May it not permit the passage of some, however deleterious, and oppose the introduction of others?

3d. The respiration of air charged with the exhalations arising from oil of turpentine, gives a peculiar odour to the urine. Remaining in a chamber newly painted, has also considerable influence on this fluid. In this case, it is very evidently by the lungs, at least in part, that the odoriferous principle passes into the blood, and thus to the kidneys;

indeed, I have several times experienced that in breathing from a large bottle, and by means of a tube, air charged with this principle, which could not then act upon the cutaneous surface, the odour of the urine is very considerably changed. If, therefore, the lungs can admit the entrance of other substances than respirable air, why may they not also admit the *mephitic* vapours of mines, subterraneous caverns, &c.?

4th. The influence of the respiration of moist air on the production of dropsies, is well known. The extent of this influence has been exaggerated by many physicians, but it notwithstanding really exists, and proves both the passage of an aqueous fluid into the blood with the air of respiration, and by analogy, the possibility of the passage of any other substance different from respirable air.

5th. If *asphixia* is produced in an animal, by *sulphurated hydrogenous gas*, and a metalic plate placed under any of the organs, a muscle, for example, some time after death; the surface of this plate next to the organ, becomes very sensibly *sulphurated.* The foreign principle, therefore, which is here united to the hydrogen, is introduced into the circulation by the lungs, and along with the blood penetrates all the parts which probably it has concurred to debilitate and interrupt in the exercise of their functions. The Committee of the Institute have observed this phenomenon, in their experiments, which manifestly and directly proves the immediate mixture of mephitic vapours with the blood, as well as their action upon the organs. I have made a similar observation in *asphixia* from the *nitrous gas*. Phenomena of the same nature are known to accompany the use of mercury, taken either internally or externally.

We should, I trust, be justified in concluding, from the phenomena already laid down, and from the observations accompanying them, that the deleterious substances float-

ing in the different *gases*, pass into the blood through the lungs; and that, carried by the circulation to the various organs, they thus impart their mortal influence. But let us pursue our inquiries on this subject, and endeavour to add other proofs to those heretofore adduced.

I am satisfied, from a great number of experiments, on the living animal, that atmospheric air, or any other aeriform fluid, may be made to pass into the blood, by way of the lungs.

Cut the trachea-arteria of a dog, so as to adapt a cock to it; force in, by means of a syringe, a quantity of gas more considerable than that which the lungs are accustomed to receive in an ordinary inspiration; and retain the gas in the bronchiæ, by closing the cock: the animal is instantly agitated, struggles, and makes violent efforts with the pectoral muscles. Then open one of the arteries, one which is situated the farthest from the heart, in the leg or foot, for example: the blood comes out spumous, and mixed with numerous bubbles of air.

If *hydrogenous* gas has been employed, you may assure yourself of its having passed with all its properties into the blood, by placing a lighted taper to these bubbles, which will immediately inflame them. I have generally made the experiment in that way.

When the frothy blood has continued to flow for about thirty seconds or less, animal life is interrupted; the dog drops with all the symptoms of that sort of death which follows the insufflation of air into the vascular system of black blood. He very soon dies, though free access be given to the air by opening the cock, and thus restoring respiration.

In general, when the blood flows from the artery, mixed with bubbles of air, the fatal effect has been already communicated to the brain, and death is certainly inevitable, whatever means may be used to prevent it.

Here it is seen that the causes which produce death are the same as those arising from the insufflation of air into a vein. The only difference is that in the first case the air passes from the lungs into the arterial system, and that in the second, it goes from the venous system and through the lungs into the arteries.

In the dissection of animals that die from these experiments, the whole vascular system of red blood, beginning with the *aortic* auricle and ventricle, is found more or less full of air bubbles. In some instances the blood passes also in this state through the general capillary system, and the vessels of black blood are found equally filled with a spumous fluid. At other times the capillaries of the whole body are the term at which the air mixed with blood stops, and then, though the circulation has continued for some time after the interruption of animal life, yet the black blood does not present the smallest bubble of air, while the red is surcharged with them.

I have never observed in these experiments, which have been very often repeated, that the bronchiæ suffered the slightest laceration; it is, however, very difficult to be assured of this in their minute ramifications; there is one phenomenon which may throw some light upon this subject: whenever air is forced into the lungs with a too great impetuosity, it occasions, besides the passage of the fluid into the blood, its insertion into the cellular texture, where it spreads, and produces *emphysema* of the breast, neck, &c. But if the impulsion is moderate, and the quantity of air simply augmented beyond the sum of a full inspiration, there is only the passage of the air in its natural state into the blood, and never a penetration of it into the cellular substance.*

---

* This fact, which has been several times confirmed in my experiments, is not always the same in man. *Emphysema* is often produced by violent

The experiments of which I have just given the detail, present phenomena which take place in a state different from ordinary inspiration: I am well aware that we cannot consequently draw from them any rigorous conclusion

---

exertions of respiration, which force the air contained in the lungs into the cellular texture. But, if the passage of the air into the blood preceded or even always accompanied its introduction into the cells of the bronchiæ, all these cases of *emphysema* would be necessarily mortal, and that too in a sudden manner, since, from what has been heretofore said, the contact of air upon the brain, whither it is carried by the circulation, inevitably interrupts the functions of this organ.

Nevertheless it is frequently observed that *emphysemas* are either cured, or do not occasion death for a very long time. In the Hotel-Dieu I have seen one of these air-tumours suddenly make its appearance in the *axilla*, while Desault was reducing a luxatur of long standing, by the violent efforts of the patient to keep in his breath. After some days the tumour disappeared without having produced any inconvenience. There are to be found in the Memoirs of the Academy of Surgery, in the treatises on operations, &c. various examples of emphysema produced by strong agitations of the thorax, from the introduction of an extraneous body into the trachea-arteria, under which the patients have lived for several days, and from which some have ent ly recovered.

It is therefore beyond a doubt that in man the air often passes from the lungs into the cellular texture, without penetrating into the arterial system. The experiments which I have made upon animals have not been exactly analogous to what happens upon the introduction of an extraneous body, where a portion of air can still have ingress and egress. It is therefore probable that from a cause exactly similar, the same effect might also be produced in animals.

The passage of air into the sanguiferous vessels sometimes reciprocally happens in man, without producing a penetration into the cellular organ; in that case death is sudden.

A fisherman, subject to windy colics, was suddenly seized with one in his boat; the belly swelled, respiration became painful, and the patient died almost immediately. He was opened the next day by Morgagni, and his vessels were found filled with air. Pechelin also relates a case of a man's having suddenly died in the pangs of a hurried respiration, and a large quantity of air being afterwards found in the heart and great vessels

respecting the passage of deleterious substances into the mass of blood; but I trust nevertheless that they confirm the possibility, which is demonstrated besides by many of the preceding remarks.

From all that has been advanced above, I do not think this passage can be denied. In fact, 1st, we have seen that the simple transmission of black blood into the arteries is not sufficient to account for the numerous and infinitely varied phenomena which take place in the different species of *asphixia;* 2d, that the simple contact upon the pulmonary nerves, of the deleterious substances found in certain

---

I have had several opportunities of dissecting subjects in which death had been preceded by a bloody congestion in the external capillary system of the face, neck, and breast. This system presented a remarkable turgidity and lividity in all those parts; and I found upon opening the arteries and veins, in those of the neck and head particularly, a spumous blood and mixed with many bubbles of air. I learned that one of these subjects had died suddenly in a convulsive affection of the pectoral muscles; I could gain no informatian with respect to the others. It must have been remarked by all who have been in the habit of attending amphitheatres, that these kinds of subjects very speedily become putrid and throw out an insupportable odour. They must have observed also that the air existed in the vessels previous to the putrefaction.

I suspect that in all these cases death was produced by the sudden passage of the air from the lungs into the blood, by which it was afterwards carried to the brain; nearly in the same manner as I have said it occurs, when a large quantity of air is thrown into the lungs of a living animal, and thus made to pass into the vascular system.

By comparing these phenomena with the observations offered above upon death by the injection of air into the veins, my reader will, I trust, admit the opinion I advance, and which has besides been supported by several physicians. Various essays relative to this point have already been made on the dead body. Morgagni gives their detail; but it is in the living individual that the passage of air into the blood should be observed, in order to draw proper inferences upon the subject which occupies us. It is known what an influence death has on the *permeability* of the parts.

mephitic vapours could not produce so rapid a death as is sometimes observed in these accidents; 3dly, that we were consequently led to suspect, from the deficiency of other causes, that of the passage of these deleterious substances into the blood; and, 4thly, that numerous considerations positively establish this passage, which is thus found to be proved, both by direct and indirect means.

This principle being once established, let us see what consequences result from it. The first of these is the mode of action which the deleterious substances exert upon the different organs to which they are carried by the circulatory current.

To attempt to look for the precise mechanism of this action, would be to quit the open path of experiment, to enter that of conjecture. I shall take up no more time in this than I did in discovering the precise manner in which the black blood acted upon those organs whose action it interrupted.

I shall confine myself therefore to examine upon what system the influence of the deleterious substances mixed with the blood in the different species of asphixia is principally exerted. Every thing tells us, 1st, that it is in general upon the nervous system, upon that particularly which embraces the parts of animal life; for the organic functions are only consequentially disturbed; 2dly, that in the animal nervous system, it is the brain which is chiefly affected; 3dly, that under this consideration, M. Pinel was right in classing among the different nervous *asphixiæ*, those, more particularly, in which there is besides the contact of black blood, the presence of a poison. The following considerations appear to me to leave but little doubt on this subject.

1st. In every case of *asphixia* where there can be no question as to the presence of a poison, in those, for in-

stance, produced by lead, the symptoms are confined almost always to two general and contrary phenomena; namely, to spasm, more particularly of the voluntary muscles, or to a torpor and heaviness similar to comatose affections. Two labourers coming out of a privy in the street of Saint-André des-Arcs, were assailed by the vapours of lead: one of them seated himself against a wall, fell asleep and was suffocated; the other ran with convulsive motions as far as Battoir street, and was also seized with *asphixia.* Monsieur Verville approached a labourer who had been killed by lead, and breathed the air which exhaled from his mouth: he suddenly fell senseless, and was soon seized with strong convulsions. The vapour of charcoal, it is said, often enebriates. I have seen animals perish in *asphixia* from other gases, with a rigidity and stiffness of the limbs, which indicated the most violent spasms. The *centre* of all these symptoms, the organ especially affected from which they proceed, is unquestionably the brain. In this case the same thing happens as when this organ is laid bare and in any manner irritated or compressed: the irritation or compression occasions sometimes *coma*, and sometimes convulsions, according to their degree, and sometimes according to the disposition of the subject. Here there is no compression, but the irritating cause is the poison carried to the brain by the circulation.

2dly. Animal life is always suddenly interrupted before the organic, in cases of *asphixia* where there is no reason to suspect that the contact of black blood only produced it. Now the centre of this life is the brain; in it the sensations and volitions have their origin. All the phenomena of our connexions with surrounding beings, therefore, should be annihilated, when the cerebral action has ceased.

3dly. I have proved that when black blood only destroys the animal, the brain is in the first place particularly affected

by its contact. Why should not the deleterious substances which, in *asphixia*, are carried with the blood by the cephalic arteries, act in the same manner upon the cerebral mass?

4thly. I have injected different deleterious gases by the carotid, *sulphurated hydrogen*, for example; and introduced into the brain some of those substances which are known to vitiate the nature of these gases, by mixing them with liquids; in every case the animal died in *asphixia*, either with spasmodic symptoms, or with those of torpor as mentioned above. In general, there is a great similarity between *asphixia* from the different deleterious gases, and death produced by offensive substances introduced through the carotid into the brain. In one of the preceding articles I have laid down several experiments relative to this subject.

5thly. All the symptoms which follow these kinds of *asphixia* when the patient returns to life, indicate an injury, and disturbance in the nervous system, particularly in that portion of which the brain is the centre. Such as *paralyses*, tremours, wandering pains, and disorders in the external sensitive system, &c. &c.

We may conclude from the foregoing considerations, that it is upon the brain, the cerebral nervous system, and consequently upon all the organs of animal life dependant thereon, that the deleterious principles taken into the great circulation by asphixia, exercise their first and principal influence, and that it is from the death of these parts that that of the others more particularly results. The different organs are no doubt also affected and debilitated directly in this case; they may die by the immediate contact of those principles which enter them with the blood; and in this respect, their action is similar to that which we have said was produced by the contact of black blood. But all these phenomena are much more prominent in

animal than in organic life, where they are no doubt developed in the same manner as we have explained by the contact of black blood.

Moreover, we must not forget, in accounting for these kinds of death, to combine the influence of this black blood with that of the poisons, though here we have omitted to consider it. This influence is the more considerable according as the circulation has continued a longer time after the first invasion of the symptoms, because the black blood has had a longer time to penetrate the organs.

From what has been said of the introduction of poisons into the blood, and of their action upon the different parts, an idea, I should suppose, may be easily formed of all the differences pointed out above in the species of asphixia they produce. The infinite variety in the nature of these poisons, must produce symptoms very different as to their intenseness, their rapidity, and the effects which they leave behind, as well in the life of the organs of those who recover from *asphixia*, as in the bodies of such as fall victims to it.

Finally, these differences depend much also upon the disposition of the subject: the same poison may, as I have said, according to this disposition, produce very different and sometimes apparently contrary effects.

SECTION II.

In the greater number of diseases, death begins by the lungs.

We have just spoken of sudden deaths; let us now say a few words on those which slowly succeed to different diseases. Whoever has witnessed the last pangs of death,

has, I presume, been persuaded that in the greater number of instances, life is terminated by an affection of the lungs. Whatever may be the seat of the principal disease, whether it be an organic defect, or a general injury of the functions, as fever, &c. almost always in the last moments of existence, the lungs are embarrassed; respiration becomes painful; the air is taken in and expelled with difficulty; the colouration of the blood is hardly carried on; it passes nearly black into the arteries.

The organs already generally debilitated by the disease, receive much more easily in that state the fatal influence of the contact of this blood, than in *asphixia* where they are unaffected. The loss of sensations and of intellectual functions, and very soon that of voluntary motions succeed the embarrassed state of the lungs. The man has no longer any connexion with surrounding objects; his whole animal life is interrupted, because the brain which, as it is known, governs this life, penetrated with black blood, ceases its functions.

By degrees the heart and all the organs of internal life imbibing this blood, cease their motions also. In this case it is the black blood which altogether stops the vital motion already enfeebled by the disease. It is in general very rare that this debility produced by the disease brings on death in an immediate manner; it paves the way to it; and renders the organs completely susceptible of being influenced by the smallest change in the red blood. But it is almost always this change which puts an end to life. The cause of the disease is therefore only an indirect cause of general death; it occasions that of the lungs, which latter brings on that of all the organs.

It may be very easily conceived, after this, why the little blood contained in the arterial system of dead bodies is almost always black, as we have already observed. Indeed,

1st, the greater number of deaths commence in the lungs; and, 2d, we shall see that those which have their principle in the brain, must also afford this phenomenon. It is therefore only in those very rare cases, where the heart suddenly ceases to act, that red blood is to be found in the aortic auricle and ventricle, or in the arteries. Such an occurrence is seldom observed except in the heart of animals that have died suddenly from excessive hemorrhagy, in that of frogs, &c. and sometimes in the bodies of those who have perished by syncope, a circumstance however in which this does not always happen.

From the frequency of deaths which commence by an embarrassed state of the lungs, it may also be conceived why this organ is almost always found choked up with blood in dead bodies. It is in general larger, and heavier, in proportion as the last pangs have been longer in duration.

When these two circumstances, namely, the presence of black blood in the vascular system of red blood, and the engorgement of the lungs by the black blood, are united, it may be said that the death of the subject commenced by the lungs, whatever may have been his disease besides. Indeed, the immediate phenomena of death (I speak not of its remote appearances) proceed always from one of the three organs, the pulmonary, the cephalic, or cardiac, to all the rest. Now we have already seen, on the one hand, that it takes its principle from the heart, the pulmonary vessels are almost entirely empty, and there is usually a presence of red blood in the aortic ventricle; on the other hand we shall find that if death makes its first approaches on the brain, black blood, it is true, will be observed in the system of red blood, but then the lungs will be found necessarily empty, unless some antecedent affection and entirely foreign to the phenomena of death shall have sur-

charged them. The marks therefore here pointed out, indicate that the first phenomena of death are developed in the lungs.

ARTICLE X.

OF THE INFLUENCE OF THE DEATH OF THE BRAIN UPON THAT OF THE LUNGS.

THE moment the brain of man ceases to act, all the functions of the lungs are suddenly interrupted. This phenomenon which is universally observed in animals with red and warm blood, can happen only in two ways; 1st, because the action of the brain is directly necessary to that of the lungs; or, 2d, because the latter receives an indirect influence from the former through the intercostal muscles and diaphragm, which influence ceases when the cephalic mass is inactive. Let us inquire which of these two modes is that fixed on by nature.

SECTION I.

An inquiry whether the lungs cease to act directly by the death of the brain.

To establish that there is no direct influence exercised by the brain on the lungs, will be to prove, I trust, that the death of the former does not directly occasion that of the

latter of these organs; now this essential principle may be very easily demonstrated by experiment.

The brain can directly influence the lungs only by means of the *par vagum* or the *great sympathetic*, these being the only nerves, according to the common opinion, which establish communications between these two organs; but according to the laws of nature, the great sympathetic is only an agent of communication between the organs and the ganglions, and not between the brain and the organs.* Now, in the first place the *par vagum* does not carry any influence to the lungs actually necessary to the functions they exercise: the following considerations and experiments will, I trust, prove this assertion.

1st. Irritate the *par vagum* on one or on both sides, in the region of the neck: respiration is at first a little accelerated; the animal is agitated; and the lungs appear oppressed. It might be supposed at first that these phenomena indicate a direct influence; but such a conclusion would be incorrect: every species of pain, whatever may be its seat or the parts it affects, almost always produces a similar phenomenon which is dispelled as soon as the irritation ceases. A simple wound in the neck, without injury to the eighth pair, occasions the same effect, if it causes the animal to suffer much.

2d. If only one of these nerves is cut, respiration becomes suddenly difficult by the effect of the pain; but the difficulty continues for some time after the cause of the pain has ceased; by degrees it is dispelled, and in fifteen or twenty hours the phenomena of life are carried on with their usual regularity.

3d. If both nerves of the *par vagum* are divided, respiration is much more accelerated; it does not recover its ordinary state as in the preceding experiment; but continues laborious for four or five days, and the animal dies.

---

* Vide note to page 57.

From the two last experiments it follows, that the nerve of the eighth pair is necessary, it is true, to the pulmonary functions, and that the brain of consequence exercises a sort of influence on these functions, but that this influence is not actual, that the lungs continue their action for a long time without it, and that it is not consequently by its interruption that respiration is made to cease all at once, in injuries of the brain.

Is the influence of the nerves which the lungs receive from the ganglions more immediately connected to their functions? The following facts will decide this question.

1st. If the nervous fillet, which is considered as the trunc of the great sympathetic is cut on both sides of the neck, respiration is scarcely disturbed in consequence. Often not the slightest mark of alteration is perceptible.

2d. If the two sympathetic and the two *vaga* are divided at the same time, death happens after a certain time, and in a manner nearly similar to that when the *vaga* only are destroyed.

3d. By cutting the sympathetic, in the neck, the lungs are not deprived of the nerves coming from the first thoracic ganglion; but these nerves may concur somewhat to keep up the action of this organ, notwithstanding the section of their trunc; since, as I have observed, each ganglion is a nervous centre which sends out its particular irradiations, independent of the other centres with which it communicates.

I have not been able to remove this very reasonable doubt, by experiments made upon these nerves themselves; for such is the position of the first thoracic ganglion, that it cannot be taken out of animals, without producing injuries so considerable, that the individual would either perish, or be thrown into such disorder, that the phenomena we look for would be confounded with those arising from

this universal disturbance. But the analogy of what happens to the other internal organs, when the ganglions from which they receive their nerves are destroyed, does not induce a belief that the lungs would cease to act the instant the first thoracic ganglion is destroyed.

Besides, the reasoning which follows appears to me to prove indubitably the principle I advance. If violent injuries to the brain suddenly interrupt respiration, because this organ can no longer influence the lungs by means of the nerves coming from the first thoracic ganglion, it is evident that by destroying the communication of the brain with this ganglion, the influence must cease, and the respiration of consequence be interrupted (for the influence can be only successively exercised, 1st, from the brain to the spinal marrow; 2d, from the latter to the last cervical and the first dorsal pairs of nerves; 3d, from these pairs to their branches communicating with the ganglion; 4th, from the ganglion to the branches which it sends to the lungs; and, 5th, from these branches to the lungs themselves). Now, if, as has been done by Cruikshank, the spinal marrow is cut even with the last cervical vertebra, and consequently above the first thoracic ganglion, life and respiration continue for a long time, notwithstanding the defect of communication between the brain and the lungs, by the first thoracic ganglion.

I have not taken into consideration the different peculiarities which accompany the section of the nerves of the lungs, which go also to many other organs, as is well known. The phenomena relating to respiration have alone occupied me: the others may be found in those authors who before me made these curious experiments, under a different view.

We may conclude, I think, from all the preceding experiments, that the brain has no direct and actual influence on the lungs; and that we must consequently look for other

causes of the sudden and instantaneous cessation of the functions of the latter, when those of the former are interrupted.

There is, however, one phenomenon which may throw some doubts on this result, and which appears to give a blow to the principle it establishes. I mean the sudden disturbance occasioned in the respiration and circulation, as I have observed, by every violent pain. Does not this disturbance indicate that the heart and lungs are under the immediate dependance of the brain? Several authors have thought so, from the following reasoning: every sensation of pain or of pleasure must certainly be referred to the brain, as the centre which perceives the sensation. Now if every violent pain hurries the circulation and respiration, it is manifest that it is the brain which, being affected, reacts upon the lungs and heart, and thus disturbs their functions. But this reasoning, as will be presently seen, is more specious than solid.

Every violent pain, whether produced in man or in animals, is almost always accompanied with a lively emotion, which is an affection of the sensitive and not of the intellectual system. It is sometimes fear and sometimes rage which agitates the suffering animal; and there are sometimes other sensations that we cannot exactly define, that we experience but know not how to express, and which enter into the class of the passions.

From this it is to be considered, that there are in the greater number of pains, 1st, sensation; and 2dly, passion, emotion, or affection.* Now I have proved that every

* The expressions *passion*, *emotion*, *affection*, &c. I am aware, offer real differences in the language of metaphysics; but as the general effect of the sensations they express is always the same on organic life, as this general effect only concerns me, and the secondary phenomena are but of little importance, I have used the words indifferently to express the same thing.

sensation is referred to animal life, and more especially to the brain, the centre of this life; and that, on the contrary, every passion or emotion relates to organic life, to the lungs, heart, &c. Therefore, though in every pain it is the brain which perceives the sensation, and though the suffering principle is to be found in this organ, yet it does not react upon the internal viscera. The disturbance therefore which affects the respiration and circulation does not depend upon this reaction, but upon the immediate influence of the passions upon the heart or lungs of the animal they agitate. The following considerations appear to me to justify these conclusions more decisively.

1st. The disturbance in the respiration and circulation often exists previous to the pain; examine the thorax, and lay the hand upon the heart of a man about to undergo an operation, or of an animal about to submit to an experiment which he has already experienced: you will be readily convinced of the truth of this.

2d. There is sometimes an evident disproportion between the sensation of pain experienced, and the disturbance produced in the circulation and respiration. A patient died suddenly after cutting off the prepuce. The operation for *fistula in ano* by ligature, was equally fatal in another, operated upon by Desault, &c. &c. But in these cases it surely was not the pain which killed (I do not believe that it ever kills in a sudden manner); death supervened in the same manner as it happens on the news of an event which affects a man with fear, or which agitates him with rage, and as I have said that syncope manifests itself, &c. The heart and lungs have been directly affected by the passion, and not by the cerebral reaction.

3d. There are many invalids sufficiently courageous to support very severe pain with indifference, and without the manifestation of any passion, or emotion: but place

the hand upon the heart of these persons, at the moment of their sufferings: you will find no alteration either in the circulation or respiration. Nevertheless their brain perceives the pain like that of others; and consequently should react equally upon the internal organs, and disturb their action.

4th. We should not judge of the state of mind in patients by their complaints or by their silence during the operations they are undergoing. These signs are illusory, because the will may sufficiently master their motions to prevent their yielding to the impulsion given to them by the internal organs: but examine the heart and lungs; their functions are, if I may use the expression, the *thermometer* of the affections of the mind. It is not without reason that an actor, in playing a courageous part, seizes the hand of whomsoever he wishes to convince, and places it against his heart, to prove that he is not intimidated by the aspect of the danger or the pain. For the same reason we should not judge of the internal state of the mind by the external motions of the passions. These motions may be either real or dissembled; real, if their principle is in the heart; and dissembled, if they come only from the brain; for in the first case they are involuntary, and in the latter they depend upon the will. Always examine therefore in persons who manifest rage, grief or pain, if the state of the pulse corresponds to the external motions. When I see a woman weep, agitated, or seized with convulsive motions, at the news of the loss of some beloved object, and find her pulse in its natural state, I conclude, that the animal life only is agitated, and that the organic continues calm. Now the passions or emotions always show their influence on the last, the emotion of this woman therefore is not lively; her motions are consequently dissembled. When I see another, on the contrary, show no external mark of extreme

distress, and find that her heart beats with violence, or has experienced some disturbance; I say then that this woman dissembles a calm which her mind does not experience. There would be no mistake if it were possible to distinguish the involuntary motions produced, in the passions, by the action of the heart upon the brain, and afterwards by the reaction of the latter upon the muscles, from the voluntary motions occasioned by the simple action of the brain upon the locomotive system of animal life. But from the impossibility of making this distinction, we must be content to compare the external motions with the state of the internal functions.

5th. However violent may be the pains in which the disturbance of the respiration and circulation of which we have spoken, comes on, this disturbance very soon ceases, though the pains last ever so long. Yet the brain which continues to perceive the pain, should continue also to react upon the lungs and heart, if this reaction was a real cause of the disturbance of their functions. Upon what then depends this quietude of the internal functions as connected with a painful affection of the brain? according to our mode of reasoning this is the explanation: we have seen that habit very soon deadens every emotion of the mind; when therefore the pain continues in force, the emotion disappears and the sensation remains; then there is no longer any direct influence exercised upon the internal organs; the brain alone is affected; and then also there is no farther disturbance in the internal functions. It will be conceived that I here speak only of those cases where the fever produced by pain has not yet disturbed the action of the heart or lungs. This intermediate mode of influence which the affections of the brain exercise on those of these organs, is not the object of my present researches.

I might add to these many other considerations, to establish, 1st, that though the brain may be the seat to which the pain is to be referred, it is nevertheless not the principle of those alterations produced in the internal organs by this pain; 2dly, that these alterations always depend upon an emotion or affection of the mind, a passion, the nature and effect of which are, as I have said, absolutely distinct from the nature and effect of every species of sensation, whether of pleasure or pain.

This phenomenon therefore does not destroy the propriety of our induction from the experiments above related; namely, that the lungs do not cease to act directly by the death of the brain.

SECTION II.

Inquiry whether the lungs cease to act indirectly by the death of the brain.

Seeing that the lungs are not suddenly destroyed by the interruption of the cerebral action, and that their death does not take place directly, there must be therefore between them and the brain, some intermediate organs, the cessation of whose functions bring on that of the lungs. These intermediate organs are the diaphragm and intercostal muscles. Subjected, by means of the nerves which they receive, to the immediate influence of the brain, they become paralytic, the moment the latter has entirely lost its action. The following experiments are in proof.

1st. The spinal marrow of a dog was cut by Cruikshank, between the last cervical and the first dorsal vertebra. The intercostal nerves, thus deprived of their communication with the brain, immediately ceased their action; the inter-

costal muscles were paralysed; and respiration was carried on only by means of the diaphragm, which receives its phrenic nerves from a point of the *medulla* superior to its division. In this experiment, which I have several times repeated, it is easy to judge of the strong action of the diaphragm, which is not seen, from that of the abdominal muscles, which is very distinctly observed.

2d. If the phrenic nerves only are divided, the diaphragm becomes motionless, and respiration is carried on only by the intercostal muscles and according to the transverse *axis*, while in the preceding case it was performed according to the perpendicular *axis*.

3d. In the two foregoing experiments, life is not destroyed for some time. But if the phrenic nerves and the *medulla spinalis* towards the end of the cervical region are cut at the same time, or what amounts to the same thing, if the *medulla* is cut above the origin of the phrenic nerves, then, as all communication between the brain and the active agents of respiration is destroyed, death is sudden.

4th. I had frequently observed in my experiments that a difference of half an inch in the height at which the section of the *medulla* was made, produced so great a difference of effect, that in the one case death happened instantly, and in the other very often not for fifteen or twenty hours. Upon dissecting dogs killed in this manner, I have constantly observed that this difference depended only on the phrenic nerve. When the section is made above it, respiration, and of consequence life, cease instantly, because neither the diaphragm nor the intercostal muscles can act. When it is made below it, life and the phenomena of respiration are still kept up for a time by the action of the diaphragm.

From the preceding experiments, it is evident that respiration ceases all at once, after the following manner,

from injuries of that portion of the nervous system which is placed above the origin of the phrenic nerves: 1st, an interruption in the action of the voluntary nerves below the injury, and of consequence in the phrenic and intercostals; 2dly, a paralysis of all or of nearly all the muscles of animal life, especially of the intercostals and diaphragm; 3dly, a cessation of the mechanical phenomena of respiration, for want of the requisite agents; and, 4thly, an annihilation of the chymical phenomena, the introduction of air into the lungs being stopped by the cessation of the mechanical phenomena. The interruption of all these motions is as rapid as their succession in the natural order.

Thus it is that patients die suddenly after receiving violent injury in that portion of the medulla spinalis situated between the brain and the origin of the phrenic nerves, which may happen by wounds, by compression, or from a displacement of the second vertebra, &c. &c.

Physicians have been much embarrassed in fixing upon the precise spot where injuries to the spinal marrow are not suddenly fatal. They have observed, generally, that the superior and inferior portion of the region of the neck, present in this respect a remarkable difference; but hitherto no precise or correct determination has been made. From what I have said, the limit may be easily ascertained: it is in every case the origin of the phrenic nerves.

Hence it is also that those die who experience a sudden and violent commotion, a strong compression, or considerable effusion in the brain, &c.

It is to be observed, however, that these different causes of death act in very different degrees. If they are weak, their sudden effect takes place only in the intellectual functions. These functions are always the first to experience a change in injuries of the brain, and are most susceptible of being influenced by slight derangements. In general all

that portion of animal life by which we receive the impression of external objects, and the functions dependant thereon, such as memory, imagination, judgment, &c. are the first to be disturbed. If the injury received is stronger, irregular and sudden starts are manifested in the voluntary muscles of the limbs; and convulsions supervene, or they are affected with paralysis, &c. Finally, if the injury is in the highest degree, all the muscles of animal life are paralysed, the intercostals and diaphragm as well as the rest. Death then suddenly ensues.

We may readily reply, after what has been heretofore said, to the question proposed in the commencement of this section, namely, that it is indirectly in principle that the death of the brain occasions that of the lungs.

It also follows from the experiments detailed above, that respiration is a mixed function, placed, to speak thus, between the two lives, and serving as a point of contact, belonging to the animal by its mechanical, and to organic by its chymical functions. Hence it is, no doubt, that the existence of the lungs is as much connected to that of the brain which is the centre of the former, as it is to that of the heart which serves as a focus to the latter.

It is observed in the series of animals that, in proportion as the cerebral organization is more contracted, respiration loses many of its phenomena. This function is much better developed in birds and mammiferous animals than in reptiles and fish, of which the cephalic mass is less in proportion, than that of the animals of the two first classes. It is known that the nervous system of animals which respire through a trachea, is less perfect and always presents peculiar dispositions; that where there is no nervous system at all, the function of respiration is wanting also.

In general, the connexion is reciprocal between the brain and lungs, particularly in mammiferous animals and birds.

The first produces the action of the second, by favouring the ingress of air into the bronchiæ, by the motion of the respiratory muscles; and the second keep up the activity of the first by the red blood which they send to it.

It would be very curious to ascertain precisely the connexion of the nervous system with respiration, in insects in which the air penetrating at different points, by tracheæ opening externally, appears to have no mechanical action, and in which of consequence respiration appears to belong entirely to organic life; whereas, as we have before observed, it holds the middle rank, in the species with distinct lungs, whether their structure be branchial or vesicular.

ARTICLE XI.

Of the influence which the death of the brain exercises upon that of the heart.

WE have seen in the last article, why the lungs remain inactive, when the brain ceases to act. The same phenomenon takes place also in the heart; this organ no longer beats after the brain is dead. Let us endeavour to find out how this happens.

It is evident that this phenomenon can take place in two ways only: 1st, because the heart is under the immediate dependance of the brain; or, 2d, because there is between these two an intermediate organ whose functions are in the first place interrupted, and which thus puts a stop to those of the first.

SECTION I.

Inquiry whether the heart ceases to act immediately, by the interruption of the cerebral action.

Physicians for the most part speak in very vague terms of the cerebral influence; they do not sufficiently determine its extent and limits, with respect to the different organs.

It is evident we shall have answered the above inquiry, if we determine what this influence is as it respects the heart. Every observation appears to prove that there is no direct influence exercised by the brain over this organ, but that on the contrary, as we have seen, it holds the former organ under its immediate control, by means of the motion which it communicates to it.

This assertion is not new: it is admitted by all correct physiologists; but as many opinions in medicine are founded upon opposite principles, it will not be thought useless, I trust, to spend a few moments in establishing this. It is demonstrated equally by observation and experiment; we shall begin with the first.

1st. Every violent irritation on the brain, whether created by a splinter, blood, or any other cause, almost always produces convulsive motions, either partial or general, in the muscles of animal life. But if those of organic life are examined under the same circumstances, the heart in particular, no disturbance will be found in their action.

2d. Every compression on the cerebral mass, whether produced by pus, water, blood, or fractured bone, very commonly acts in an inverse manner, that is to say, it affects the voluntary muscles with paralysis. But, so long as the affection does not extend to the pectoral muscles, the action of the heart is not at all diminished.

3d. Opium, or wine taken to a certain quantity, diminishes for a time the cerebral energy, and render the brain unfit for the functions relating to animal life. But, in this momentary enervation, the heart continues to act as usual, and indeed its action is sometimes increased.

4th. In palpitations, and in various irregular motions of the heart, the principle of these derangements is not observed to exist in the brain, which is then perfectly unaffected, and continues its action as usual. Cullen was deceived in this, as on the subject of syncope.

5th. The numerous phenomena of apoplexy, epilepsy, catalepsy, &c. &c. which have their principal source in the brain, appear to me to throw great light on the existing independence of the heart on this organ.

6th. Every organ subject to the direct influence of the brain, is of consequence voluntary. But I believe, notwithstanding the observation of Stahl, no person ranks the heart among these kinds of organs. What would life be, if we could suspend at will, the motion of the organ which animates it?

I trust we may already conclude, without fear of error, from simple observation, that it is not immediately the heart ceases to act, when the cerebral functions are interrupted. But let us rest this fundamental *datum* of physiology and pathology, upon experiments.

1st. If the brain of an animal is laid bare and irritated in different ways, by mechanical, chymical, or specific agents, or if it is compressed, &c. various changes are produced in the organs of animal life; but the heart constantly remains in the execution of its ordinary functions, so long as the pectoral muscles are not paralysed.

2d. Various experiments made upon the spinal marrow laid bare in the region of the neck, present precisely the same result.

3d. If the nerves of the eighth pair, of which several filaments go to the heart, are irritated, the motion of this organ is not quickened; nor is it stopped, if the two truncs are divided. It must be recommended however to those who repeat these experiments, to distinguish well what belongs to the emotion, and various sensations of fear, anger, &c. produced in the animal undergoing the experiment, from what is the result of the irritation or division of the nerve.

4th. Besides the eighth pair, the nervous trunc, which is called the *great sympathetic*, furnishes various branches to the heart which are distributed in its substance, and by which the brain might influence it, at least according to the common opinion which places the origin of this nerve in one of those proceeding from this medullary mass. But I have already said that the nervous system of the great sympathetic was absolutely independent of that of the brain; that there was indeed no nerve which deserved this name; that what was taken for this nerve was a series of communications between a great number of small nervous systems, all independent of each other, and all of which have a ganglion as their centre, in like manner as the great nervous system of animal life has the brain as its centre. It appears to me that this manner of regarding the great sympathetic, throws some light upon the heart's independence of the brain; but let us pursue the train of experiments calculated to establish this independence.

5th. If the experiments first made upon the *vagum* or upon its different branches which come from the brain, are repeated upon the cardiac filaments of the sympathetic, all of which come directly or indirectly from ganglions, the results are perfectly similar. There is no disturbance in the motions of the organ; they are neither augmented when the nerves are irritated, nor diminished when they

are cut; a circumstance which always takes place in the muscles of animal life.

I do not offer the details of these experiments, most of which are known, but have simply repeated them with exactness, as all authors are not of the same opinion with respect to the phenomena resulting from them.

There is another mode of experiment somewhat similar to these, which may throw farther light upon the connexions of the heart and brain: namely, galvanism. I shall not neglect this means of proving that the first of these organs is always actually independent of the second.

I have made these experiments with an attention the more scrupulous, inasmuch as several very deserving authors have lately advanced a contrary opinion, and have endeavoured to establish that the heart and other muscles of organic life do not differ with respect to their susceptibility of galvanic influence, from the various muscles of animal life. I shall in the first place mention what I have observed in animals with red and cold blood.

1st. In a frog I have several times armed the brain on the one hand with lead, and the heart and muscles of the inferior limbs on the other hand with a long plate of zinc, which touched the first at its superior extremity and the second at its inferior. The communication established with silver between the armatures of the muscles and those of the brain, constantly produced motions in the limbs; but there was no sensible acceleration in the heart while it continued to beat; nor was there any manifest motion when it had ceased to be in action. Whichsoever of the voluntary muscles be armed at the same time with the heart, in order to compare the phenomena which they experience at the time of the metallic commotion, there is always a striking difference.

2d. In other frogs I have on the one hand armed with a common metallic rod the cervical portion of the spinal marrow in the superior region of the neck, so as to be above the spot where the nerves which go to the sympathetic and thence to the heart, take their origin, and on the other hand the heart and one of the voluntary muscles. Upon establishing the communication, I have constantly observed a result similar to that of the preceding experiment. Violent agitations in the voluntary muscles were always perceptible, without any manifest change in the motions of the heart.

3d. I have endeavoured to lay bare the nerves which go to the heart in frogs; several grayish filaments scarcely perceptible, and whose nature, I confess, I could not positively ascertain, were armed with one metal while the heart rested on another. The communication established by a third, produced no sensible effect.

It appears to me that these attempts, already partly made before me, are well calculated to determine positively whether the brain influences the heart directly, particularly if care is taken, as I have done, to repeat them by successively and alternately arming the internal and external surface as well as the substance itself of the last organ. In all these trials, indeed, the natural disposition was preserved between the different parts which serve to unite it to the brain.

There is another mode of experiment, which consists, 1st, in detaching the heart from the breast; 2d, putting it in contact with two different metals, at two points of its surface, or with portions of flesh armed with metal; 3d, making the armatures communicate by means of a third metal: in this way Humbolt has seen motions manifest themselves. I must acknowledge that after having often repeated these experiments strictly as they are pointed out,

I have never observed any thing similar. At times however a slight motion, very different from that which then animated the heart, was perceptible, and appeared to proceed from the galvanic influence. But I should have taken this motion for an effect of the mechanical irritation of the armatures, had it not been for the respectable authority of this author and a number of other eminent physicians, who in their essays have recognized the influence of galvanism upon the heart when applied in this manner. I am far from presuming to see better than those who have been engaged in the same experiments; I simply mention what I have observed.

Besides, experiments in which the armatures can have no effect, upon a portion of the nervous system on the one hand, and on the fleshy fibres of the heart on the other hand, do not appear to me to lead to any decisive conclusion with respect to the direct influence of the brain upon the former organ. What correct induction can be drawn from the motions produced by an armature of the two fleshy portions?

I come now to experiments made upon animals with red and hot blood: they are so much the more necessary as the mode of contractibility in animals with red and cold blood is known to differ very materially from that of the former.

1st. I had authority, during the winter of the year 7 (1798) to make different experiments upon the bodies of those *guillotined*. They were at my disposal thirty or forty minutes after the execution. In some every species of *mobility* was extinct; and in others this property was restored with greater or less facility in all the muscles, by common agents. It was developed, particularly in the muscles of animal life, by galvanism. But it was in all impossible to produce the slightest motion by arming, either the spinal marrow and heart, or this last organ and the nerves which

it receives from the ganglions by the sympathetic, or from the brain by the *par vagum*. Mechanical *excitants* however directly applied to the fleshy fibres, produced contraction in them. Was this occasioned by the nervous filaments of the heart having been for some time without connexion with the brain? But then, why should the voluntary muscles, equally removed from the connexion, yield to galvanic phenomena? The following experiments will tend to clear up this doubt.

2d. In dogs and guineapigs, I armed with different metals in the first place the brain and heart, then the trunc of the medulla spinalis and the last organ, and finally the same organ and that nerve of the *par vagum* from which it receives several nerves. The two armatures being made to communicate, no sensible effect resulted; I neither observed the motions to be restored after they had ceased, nor to be accelerated while they continued.

3d. The cardiac nerves of two dogs were armed, in their anterior as well as posterior filaments; another armature was placed on the heart, at one time in its internal surface, at another on its external, and sometimes in its texture. The communication did not produce any apparent motions. In all these experiments, the communication should not be established until some time after the armature of the heart has been placed, that what is simply the effect of metallic irritation may not be attributed to galvanism.

4th. Humbolt says that when the heart is detached suddenly and with care to leave some of its isolated nerves in it, contractions may be excited by arming the latter with a metal, and touching the armature with another metal: I have in vain attempted it several times; on one occasion however it appeared that I succeeded.

5th. On the contrary I have almost constantly succeeded in producing contractions in animals with red and hot

blood, by taking out the heart and putting it in contact at two different points, with metals, and establishing a communication. I believe this is the only means of effectually producing galvanic phenomena upon this organ. But this mode, already often exemplified, by Jadelot in particular, affords no proof of what we are now looking for; namely, whether there is a direct influence exercised by the brain upon the heart.

I have repeated every one of these experiments on galvanism a great number of times, and with the most scrupulous precautions. However I do not pretend, as I have said, to throw any doubts upon the reality of those which have afforded different results to some very able physicians. It is well known the effects of experiments made upon the vital powers are very variable. Besides, even admitting the results which differ from mine, it cannot be denied that with respect to galvanic excitement, there is an enormous difference between the muscles of animal and those of organic life. Nothing can serve more readily to point out this difference, in experiments upon the heart and intestines, than always to arm one of the muscles of animal life, with the same metal which is used for the armature of these muscles, and thus establish a parallel between them.

Moreover, supposing that the galvanic phenomena had equal influence upon these two species of muscles, what would this fact prove? nothing more than that these phenomena were governed by laws quite contrary to those of the phenomena of common irritation on the nerves and muscles to which these nerves correspond.

Thus have I offered a sufficient number of proofs drawn from observation of diseases as well as from experiments, to answer, I trust, the question proposed in this section, and to justify the assertion that the brain exercises no di-

rect influence on the heart; and that consequently when the first ceases to act, it is indirectly only that the functions of the second are interrupted.

SECTION II.

Inquiry whether, in injuries of the brain, the death of the heart is caused by that of an intermediate organ.

Since the cessation of the functions of the heart is not direct in great injuries of the brain, and that this cessation nevertheless takes place suddenly, it necessarily follows that there must be some intermediate organ, whose interruption of action must be the proximate cause. Now this organ is the lungs. What follows is the usual concatenation of phenomena, in the death of the heart produced by that of the brain.

1st. An interruption of the cerebral action; 2d, an annihilation of action in all the muscles of animal life, and of course in the intercostals and diaphragm; 3d, the consequential cessation of the mechanical phenomena of respiration; 4th, a suspension of chymical phenomena and consequently of the colouration of the blood; 5th, the penetration of black blood into the fibres of the heart; and 6th, the debility and cessation of action of these fibres.

The death which succeeds violent injuries of the brain, has therefore considerable resemblance to that from the different species of *asphixia;* it is only more speedy, for reasons which I shall point out. The following experiments evidently prove that the phenomena of this death take place in the order I have just mentioned.

1st. I have always found black blood in the system of red blood of all animals killed by commotion, cerebral

compression, &c.; the heart is livid, and all the surfaces are coloured nearly as in *asphixia.*

2d. I opened the carotid artery of a dog: red blood immediately flowed from the opening; the artery was then tied, and the animal killed by a violent blow on the *occiput.* Animal life was instantly destroyed; all voluntary motion ceased; the mechanical, and by a necessary consequence, the chymical functions of the lungs were stopped. The artery was then untied, and black blood flowed in a weaker stream than common; this stream was diminished, at length interrupted, and the blood came away by drops. Finally the motion of the heart ceased after some minutes.

3d. I have constantly obtained a similar result upon opening an artery in different animals that were afterwards killed either by a division of the medulla between the first vertebra and the occiput, by strong compression on the brain previously laid bare, or by the entire destruction of this organ, &c. It is in the same way those animals die, which have had deleterious substances forced into the brain by the carotid.

4th. The preceding experiments account for the blackness of the blood which flows from the opened arteries of animals bled in slaughter houses, after being knocked on the head. If the blow has been very violent, the blood comes out nearly as it was in the veins. If it has been slight, and the action of the diaphragm and intercostals has been only weakened instead of being suddenly stopped, the redness of the blood is merely a little darkened, &c. In general, there is a constant connexion between the different degrees of colour, and the violence of the blow.

Considerable use is made of the blood of animals at our tables. No doubt there is a difference between the black and red; that one would in some cases be preferable to the other. Either may be obtained at pleasure, by bleeding

the animals before or after having knocked them on the head, because in the first case respiration continues while the blood is running, and in the second it has ceased before the bleeding begins.

In general, the state of respiration which during large hemorrhages is altered by numerous causes, creates peculiar varieties in the colour of the blood taken from the arteries: hence it is that in important operations, such as amputation, for cancer, sarcocele, &c. so many different shades are found in arterial blood. It is well known that in the commencement it sometimes flows very red, and towards the end of the operation very dark. If you examine the breast during these changes, you will constantly find that respiration is carried on perfectly while the colour continues red, and that on the contrary it is embarrassed when the colour grows dark.

While acting as an assistant to Desault in his operations, I had occasion to observe several times, both the varieties and their connexion with respiration. This connexion had attracted my notice even before I knew the cause of it. I have since established it by a great number of experiments on animals. It was clearly demonstrated by me in the extirpation of a cancerous tumour of the lips which I performed during the last year.

In general, arterial blood seldom flows so black as that from the veins, in operations; its colour merely becomes more or less shaded.

I have never found, in my experiments, any connexion between the dark colour of this kind of blood, and the compression made above the artery, as some have asserted. There certainly exists one between the colour and *impetuosity* of the stream, which is in general weakened when this colour has become deeper for some minutes. But it is in respiration that the principle of this connexion is to be

found, which may be easily explained from what has been said in different parts of this work. But let us return to the point from which we have wandered.

I trust from all the considerations and experiments contained in this article, the manner in which the heart ceases to act by the interruption of the cerebral functions, can be no longer called in question, and that we may assert positively, that the lungs are the intermediate organ whose death brings on that of the heart, which latter cannot take place directly.

There is this difference therefore between the death of the heart by that of the brain, and the death of the brain by that of the heart, that in the first case the death of one is only an indirect cause of that of the other; and that in the second case, on the contrary, this cause acts directly, as we have seen above. If certain persons have ever been able voluntarily to suspend the palpitations of the heart, this does not prove, as the disciples of Stahl assert, the influence of the mind upon the motions of organic life, but simply upon the mechanical phenomena of respiration, which in this case must have been previously stopped, as well as the chymical phenomena.

In animals with red and cold blood, in reptiles particularly, the death of the heart does not so readily succeed to that of the brain as in animals with red and hot blood. The circulation still continues for a very long time in frogs, salamanders, &c. after the cephalic mass has been taken away. Of this I have been assured by frequent experiments.

This phenomenon will be readily conceived, if it is recollected that respiration may be suspended for a long time in animals, without the motions of the heart being thereby stopped, as may be proven by forcing them to remain under water longer than their accustomed time.

In fine, as from what has been said, the heart does not cease its action, when that of the brain is interrupted, but because of the previous death of the lungs, it is manifest that there must exist between the violent death of the brain and that of the heart, an interval nearly equal to the time for which respiration may be suspended in a natural state.

ARTICLE XII.

OF THE INFLUENCE WHICH THE DEATH OF THE BRAIN EXERTS UPON THAT OF ALL THE ORGANS.

UPON calling to mind in this place the division of the organs into two great classes, namely, into those of animal, and into those of organic life, it will be seen at once that the functions of the organs of the first class must be interrupted the very moment the brain dies. Indeed, all these functions either directly or indirectly have their seat in this organ. Those which only indirectly belong to it, are the sensations, locomotion and voice, functions which are executed by other organs, it is true, but which, having their centre in the cephalic mass, cannot continue to act after the latter has ceased. On the other hand, whatever, in animal life, depends immediately upon the brain, as imagination, memory, judgment, &c. can evidently never be exercised but when this organ is in activity. The great difficulty therefore rests upon the functions of organic life. Let us endeavour to find out how they end in the present case.

SECTION I.

Inquiry whether the interruption of organic functions is a direct effect of the cessation of cerebral action.

We shall have recourse here as in the preceding article to observation and experiment, to prove that all the internal functions, as well as the action of the heart, are abstracted from the immediate empire of the brain, and that consequently their interruption cannot be immediately derived from the death of this organ. I shall begin with observation.

1st. There are numerous maladies of the brain which, when existing in a high degree, occasion an almost general suspension of animal life, and which leave neither sensations nor voluntary motions, except those feeble agitations in the intercostals and diaphragm which serve to keep up general life. But in this state in which man has lost the half of his existence, the other half, made up of organic functions, still continues and often a very long time with the same energy. The secretions, exhalations, nutrition, &c. are carried on nearly as usual. Phenomena of this kind are presented to us every day in apoplexy, commotion, cerebral inflammation, &c. &c.

2d. In sleep, the secretions are certainly carried on, though Bordeu advances the contrary opinion, to prove the influence of the nerves upon the glands: digestion also goes on perfectly at this time; all the exhalations, sweat in particular, are often increased beyond the ordinary degree; nutrition continues as usual, and there are many very substantial proofs in favour of the opinion of those who maintain that it increases while animals are asleep. Now it is well known, and it especially follows from what we have

said in the first part of this work, that sleep comes on because the brain, enfeebled by the long-continued exercise of its functions, is under the necessity of suspending them for a certain time. The relaxation of the internal organs therefore, is not a consequence of that of the brain; the influence which it exercises over them is not direct; and therefore when it dies their action is not immediately interrupted.

3d. The sleep of dormant animals affords a still better opportunity than common sleep, of contrasting the interruption of animal life and of the cerebral functions, in consequence, with the permanence of organic life.

4th. In the different kinds of paralysis, in those for instance, which affect the inferior limbs and the viscera of the lower belly, after a commotion or compression of the inferior part of the spinal marrow, the communication of the paralysed parts with the brain, is either entirely destroyed, or at least greatly enfeebled. It is destroyed when all kind of feeling or motion has ceased; and only weakened when either of those properties remains. In these two cases, the general and capillary circulation continue; exhalation is carried on as usual in the cellular texture and cutaneous surface; absorption still goes on, since without it dropsy would ensue; secretion may take place also; there is nothing indeed more common, in complete paralyses of the bladder, than an abundant secretion of mucous humour in the internal surface of this organ. As to nutrition, if it is a little diminished in the different species of paralysis, it is evidently never entirely suspended.

5th. Those spasms and convulsions which arise from a preternatural energy in the cerebral action, and which have such visible influence on the external functions, have but little, and often no effect at all upon the exhalations, secretions, circulation, and nutrition of the parts in which they

are seated. In these various morbid appearances there is one thing worthy of remark, namely, the calm which organic life retains, compared with the disturbance and confusion of animal life in the limb or part affected.

6th. Acephalous fœtuses, while in the uteris, possess an organic life altogether as active as the most perfectly-formed fœtus; indeed they sometimes discover at birth a preternatural proportion of increase. This I had an opportunity of witnessing in two fœtuses of this description that were brought to my amphitheatre during the last year: not only was the face better developed, as is always the case, because the cerebral vascular system being void, that of the face is proportionably increased; but all the parts, those of generation particularly, which generally before birth are scarcely evolved, displayed a correspondent plenitude of development. Nutrition, circulation, &c. are therefore as active in these as in ordinary cases, though the cerebral influence is absolutely wanting.

7th. It is well known that, in animals without the brain, and in those also in which there is no apparent nervous system, as in polypi, the capillary circulation, absorption, nutrition, &c. are carried on with the same perfection. It is well known also that most of the organic functions are common to the animal and vegetable; that the latter really lives organically, though its functions are influenced neither by a brain, nor by a nervous system.

8th. If we reflect a little upon the different proofs which Bordeu gives of the nervous influence upon the secretions, we shall see that none of them positively establishes the actual action of the brain upon this function. There is but one of them at all striking, namely, the sudden interruption of the secreted fluids by a division of the nerves of the different glands. But I know not whether such a division could be correctly made. A great deal is said of an experiment of

this nature, made upon the parotid glands. The disposition of the nerves of this gland renders this experiment so visibly impossible, that I have never attempted to repeat it; it is practicable only in the gland. I therefore separated the cord of the spermatic vessels of a dog; and the nerves were cut without touching the vessels. I was not able to judge of the effects of this experiment with respect to the secretion of semen, because inflammation supervened in the testicle when a collection of it was afterwards formed. But does not this inflammation, as well as the suppuration, formed without the nervous influence of the brain, suppose the possibility of secretion, independent of this influence? In this experiment the spermatic artery cannot be separated from the plexus which it receives from the great sympathetic, so inextricable is the entanglement of these nerves. But, their division is of little consequence, seeing that they come from ganglions: the essential point is to break off all communication with the brain, by destroying the lumbar filaments.

To these I might add numerous other considerations, most of which have been already noticed by other authors, to prove that organic functions are under no actual dependence on the brain, and that of consequence when the latter dies, they do not directly cease to be in activity.

It is here more particularly that the distinction of sensibility and contractibility, into animal and organic, deserves to be attentively considered. Indeed, the idea of sensibility, in our common way of viewing things, almost always recalls that of the nerves, and the idea nerves brings with it that of the brain; so that these three things are scarcely to be separated: however it is in animal life only that they should be really connected; in organic life they ought not to be associated, at least directly.

I do not say that the cerebral nerves have no influence upon organic sensibility; but I do maintain, according to

observation and experiment, that this influence is not direct, that it is not of the same nature with that observed in animal sensibility.

Several authors are already aware that the opinion which places the exclusive and immediate seat of feeling in the nerves, is subject to numerous difficulties; and they have endeavoured to find out some other means of explaining this great property of living bodies. But the same difficulty awaits our researches after the agents, as after the nature of sensibility: we should wander on eternally in darkness, the moment we quit the plain path of experiment; and this question does not appear to me susceptible of this mode of inquiry.

Let us be contented therefore to collect facts, examine and compare them together, and make ourselves acquainted with their general results. Such inquiries can form the only true theory of vital powers; all beyond it is conjecture.

Besides the considerations which I have just offered, there is another which appears to me to prove very clearly that organic functions are not under the immediate influence of the brain. It is this, that most of the viscera appertaining to these functions, receive few or no cerebral nerves, but many filaments proceeding from the ganglions.

This anatomical fact may be observed in the liver, kidneys, pancreas, spleen, intestines, &c. &c. In the organs of animal life also there are often nerves which serve the external, and others the internal functions; the one set coming directly from the brain, the others from the ganglions. Thus the ciliary nerves arising from the ophthalmic ganglion, serve to the nutrition and secretions of the eye, while the optic coming directly from the brain, serves directly to vision. Thus also the acoustic in the pituitary is the agent of the perception of odours, while the filaments of the ganglion of Mekel have no connexion but to the organic phenomena of this membrane, &c.

But the nerves from the ganglions cannot transmit the cerebral action; for we have seen that the nervous system belonging to these bodies, should be considered as perfectly independent of the cerebral nervous system; that the great sympathetic does not take its origin from the brain, spinal marrow or nerves of animal life; that its origin is exclusively in the ganglions; and that, properly speaking, this nerve does not exist, but is simply an assemblage of as many little nervous systems as there are ganglions, which are the particular centres of organic life, similar to the great and only nervous centre of animal life, which is the brain.

I could add many other proofs to those adduced above, to establish that the great sympathetic does not really exist, and that the nervous communications which have been mistaken for it, are merely accessories to the systems of ganglions. Some of those proofs follow: 1st, these nervous communications are not met with in the neck of birds, where, as M. Cuvier has observed, no trace of the great sympathetic, between the superior cervical and the first thoracic ganglion is to be found. The superior cervical ganglion is therefore, in birds, what the ophthalmic, and the ganglion of Mekel are in man, that is to say, independent and unconnected with the other little nervous systems of which each of the inferior ganglions forms a centre; notwithstanding the want of communication, however, the functions are equally well carried on. This natural disposition in birds, agrees very well with that not common to man, but which I have sometimes observed between the first lumbar and the last thoracic ganglion, between the lumbar ganglions themselves, and also between the sacral. 2d, There is often no ganglion at the spot where the pretended sympathetic nerve communicates with the spinal marrow. This is manifest in the neck of man, in the ab-

domen of fish, &c. &c. Does this disposition prove that the origin of the sympathetic is in the spinal marrow? No; it simply indicates a communication less direct than in the other parts between the ganglions and the nervous system of animal life. This disposition should be looked upon in the following way: the inferior cervical ganglion furnishes a large branch which goes to the superior, in order to establish a direct communication between them; but in ascending it distributes various branches to each cervical pair, which form a secondary communication.

Let us now compare these considerations to those set forth in the note to page 57, and we shall be more and more convinced, 1st, that the great sympathetic is nothing more than an assemblage of little nervous systems, having each a ganglion as its centre, and being all independent of each other, though usually communicating with themselves and with the spinal marrow; 2d, that the nerves belonging to these little systems cannot be considered as a dependance of the great nervous system of animal life; and, 3d, that the organs provided exclusively from these nerves, of consequence are not under the immediate dependance of the brain.

It must not be thought however that all the organs appropriated to the internal functions, receive their nerves exclusively from the ganglions. To several, they are furnished by the brain; and nevertheless experiments prove equally in these organs, that their functions are not under the immediate influence of the cerebral action.

Hitherto we have nothing but reasoning and observation as the basis of the important principle under consideration; namely, that the internal or organic functions do not directly cease by the death of the brain. But experiments upon living animals will render it no less evident.

1st. I have always observed that upon artificially producing paralyses or convulsions in the cerebral nerves of the different parts, they do not very sensibly or suddenly alter, either the exhalations, absorption, or nutrition of those parts.

2d. It has been long known that by irritating the nerves of the ganglions which go to the stomach, intestines, bladder, &c. no spasm is produced in the fleshy fibres of these organs, as is the case in the muscles of animal life by the irritation of the cerebral nerves which are distributed to these muscles.

3d. The division of the nerves of the ganglions does not suddenly paralyse the hollow organs, the vermicular motion of which continues a longer or shorter time after the experiment.

4th. I repeated the same galvanic experiments with respect to the stomach, intestines, bladder, matrix, &c. the results of which with respect to the heart have been already explained. I, in the first place, armed with two different metals, the brain and each of these viscera in particular; no contraction was apparent at the moment of communication between the two armatures. Each of these viscera was then armed at the same time with that portion of the spinal marrow situated above them. Lastly, I armed at the same time, the nerves which some of them receive from this medullary chain, and the organs themselves: thus the stomach and the nerves of the par vagum, the bladder and the nerves which it receives from the lumbars were armed together. But, in nearly all these cases, the communication of the two armatures produced very little effect; in the last only, I twice perceived a slight contraction in the stomach and bladder. In these different experiments, I produced nevertheless violent agitations in the muscles of animal life, which I always armed with the same metal already made

use of for the muscles of organic life, that I might have a term of comparison.

5th. In all the preceding cases, they were the different portions of the cerebral nervous system which were armed at the same time with the organic muscles. I was willing also to galvanize the nerves of the ganglions with the same muscles. The breast of a dog being opened, the great sympathetic, which may be easily armed with a metal, is found under the pleura. As, according to common opinion, this nerve is distributed throughout the whole lower belly, upon arming any of the viscera which are found within it, and establishing the proper communications, I ought to have expected contractions, such as are produced by arming the *facis* of lumbar nerves and the different muscles of the thigh. No effect however was apparent.

6th. According to our view of the sympathetic nerve, this defect in the result may be easily conceived. In fact, the intermediate ganglions to the gastric organs and nervous trunc of the breast, obstructed the galvanic phenomena. I therefore laid bare the nerves which go from the ganglions directly to the stomach, rectum and bladder, and by this means galvanized these different organs: in general no contraction appeared to be the consequence; sometimes a very slight one was perceptible; but very feeble in comparison to those violent contractions observable in the muscles of animal life. I cannot here forbear again cautioning the experimenter to distinguish clearly what belongs to the mechanical contact of the metals, from the simple effect of galvanism.

7th. These experiments are difficult on the intestines on account of the tenuity of their nerves. But as these nerves form a pretty considerable plexus around the mesenteric artery which distributes itself along with them in the texture of these organs, by laying this artery bare, and sur-

rounding it with a metal, while another is placed on some part of the intestinal tube, it may thus be galvanized. But the result was not more manifest in this experiment than in others.

8th. All the foregoing experiments were made upon animals with red and hot blood; I have tried the same upon animals with red and cold blood. The brain and muscular viscera of the abdomen of a frog, the same viscera and the cervical portion of the spinal marrow, were armed at the same time with two different metals. Nothing was observable at the instant of their communication, and yet the muscles of animal life were generally contracted, even without being armed, and by the simple contact of a metal upon the armature of the nervous system. It was not for want of multiplying the points of contact upon the gastric viscera, that I failed of success; for I took care to pass a leaden wire through almost the whole intestinal tube by way of armature.

9th. As to the nerves which go directly to the fleshy fibres of the gastric organs, they are so small in a frog, that it is difficult to arm them. Nevertheless, Mr. Jadelot, in one experiment, obtained a slow contraction of the walls of the stomach, by acting directly upon the nerves of this organ. But this contraction, such no doubt as I have often observed in other experiments, can certainly not be placed on a parallel with the astonishing effects produced in the voluntary muscles; and we shall not be wrong in saying that, with respect to galvanic phenomena as in all others, there is a wide difference between the muscles of animal and those of organic life.

These proofs, I think, are more than sufficient to resolve with certainty the question proposed in this section, in establishing as a fundamental principle, 1st, that the brain does not influence the organs and functions of internal life in a

direct manner; 2d, that, of consequence, the interruption of these functions, in violent injuries of the brain, is not an immediate effect of such injuries.

I am nevertheless far from regarding cerebral action as entirely foreign to organic life; but I believe I am justifiable in maintaining that this life receives from it only secondary and indirect support, of which we yet know very little.

If I have been somewhat prolix upon this subject, it is because there is nothing in medicine more vague than the sense commonly attached to the words *nervous action*, *cerebral action*, &c. What belongs to the powers of one life is never sufficiently distinguished from that which is the attribute of the powers of the other. Cullen particularly may be reproached with having too much exaggerated the influence of the brain.

SECTION II.

Inquiry whether the interruption of the functions of organic life is an indirect effect of the cessation of cerebral action.

Since organic life does not immediately cease by the cessation of cerebral action, there must therefore be some intermediate agents which by their death produce this cessation. These agents are principally, as in the death of the heart by that of the brain, the mechanical organs of respiration. The following is the course of phenomena which takes place.

1st. An interruption of cerebral functions; 2d, a cessation of the mechanical functions of the lungs; 3d, an annihilation of their chymical functions; 4th, the circulation of

black blood in all the parts ; 5th, a feebleness of the motion of the heart and of the action of all the organs ; and, 6th, an entire suspension of this motion and action.

All the internal organs then die nearly as in asphixia, that is to say, 1st, because they come in contact with the black blood; 2d, because the circulation ceases to communicate to them the general motion requisite for their action, the effect of which motion is independent of that which the blood produces by the principles it contains.

There are however many differences between death by asphixia, and that from violent injuries of the brain. 1st, Animal life is commonly interrupted in the second, at the very instant of the blow; in the first it only happens in proportion as the brain is penetrated by black blood. 2d, It is some time before the circulation ceases in most cases of asphixia, whether because the colouration into black be gradual, or because the agitation of the limbs and all the organs of voluntary motions, keep it up so long as the brain can produce those motions. On the contrary, in injuries of the brain, on the one hand the interruption of respiration being sudden, the blackness of the blood is not produced by degrees; on the other hand animal life being all at once arrested, all the organs become instantly immovable, and can no longer favour the motion of the blood. This observation is particularly applicable to the breast, the walls of which in a peculiar manner assist pulmonary circulation, and the motions of the heart also, by their alternate elevation and depression. This is the real mechanical influence which the circulation receives in respiration. That which arises from the dilatation or contraction of the lungs, is absolutely false, as we have seen.

Furthermore, the two kinds of death, one of which commences in the lungs and the other in the brain, may resemble each other or not, according to the manner in which

they happen; and this in a great measure depends upon the differences which I have pointed out being general. Thus, when asphixia is sudden, as, for example, when a vacuum is suddenly created in the trachea-arteria, by pumping the air out of it with a syringe, there are neither livid spots nor an engorgement of the lungs; the circulation ceases very speedily: this death is similar to that in which the life of the brain is suddenly destroyed.

On the contrary, if the blow which strikes this last organ, has no other effect than greatly to change its functions, and still permits the *inspiratory* muscles to have a feeble exercise for a certain time, the general capillary system may be also penetrated with blood in different parts. The circulation is then slow in ceasing. This death has some resemblance to that of many cases of asphixia.

Hence it may be conceived that the death, the principle of which is in the brain, and that which commences in the lungs, resemble or differ from each other, according as the cause which affects one of these two organs, acts with more or less promptitude or slowness. The series of phenomena is always nearly the same, particularly when the first is affected: the cause of this concatenation does not vary, but the phenomena themselves present numerous varieties.

It has been often asked how those die who are hanged: some have supposed that there was a luxation of the cervical vertebræ, a compression of the spinal marrow, and consequently a death nearly resembling that which is the effect of a commotion or a depression of bony pieces of the cranium. Others have asserted that their death was caused by the defect of respiration only. I had an opportunity of dissecting a person hanged where there was no luxation, but a fracture of the third cervical vertebra. I suspected, it is true, that this solution of continuity did not happen at the moment of the accident. It was a female who

had committed suicide; the agitation of the neck could not therefore have been very considerable. It was no doubt an effect produced upon the body after death, by a fall, a false position, &c. a circumstance however which I do not recollect to have seen in other dead bodies. But, whether persons hanged perish by a compression of the medulla, which certainly does not always happen, or whether death is occasioned simply by defect of respiration, the connexion of phenomena is not very different in either case. When there is a luxation, there is always a simultaneous asphixia also; and then this affection is produced, on the one hand directly, because the pressure of the cord intercepts the passage of the air; and on the other hand indirectly, because the paralysed intercostals and diaphragm can no longer dilate the breast to receive this fluid.

In general, there is more connexion between the two modes by which the death of the brain or that of the lungs produce the death of the organs, than between one of these two first modes, and that by which all the parts die, by the death of the heart.

From what I have said, a comparison of these three kinds of death, I presume, may be readily made; a comparison which appears to me very important, and of which the following are some of the features:

1st. There is always black blood in the system of red blood, when death commences by the brain or lungs; on the contrary this system often contains red blood, when the heart suddenly ceases its functions.

2d. The circulation continues for some time in the two first cases; in the third it is suddenly stopped.

3d. It is on account of the absence of its general motion, that the blood ceases to support the life of the organs, when their death proceeds from that of the heart: it is also partly in this way, but principally from the nature of the elements

which compose the blood, that this fluid can no longer excite the action of the same organs, when their death is produced by that of the lungs or brain, &c. &c.

I merely point out the parallel of the different phenomena of this kind of death; the reader will easily perform the rest.

In animals with red and cold blood, the death of all the organs succeeds much more slowly to that of the brain, than in animals with red and hot blood. It would be difficult to assign a reason for this fact, because we are not yet very well acquainted, either with the difference between arterial and venous blood, in animals, or with the connexion which the contact of either has with the life of the organs.

When reptiles, the frog for example, remain long under water, does the arterial blood become black for want of respiration, and do these animals then escape death, because the contact of this blood is less fatal to their organs than to those of animals with hot blood? or, does the venous blood still continue to become red, because the air contained as it were in a reservoir, in the large vesicles of these animals, can be only slowly exhausted, seeing that very little blood passes into their pulmonary artery, which is nothing more than a branch of the aorta? The experiment by which we have seen that the red colouration is prolonged, by the injection of a good deal of air into the trachea-arteria of dogs and other animals with hot blood, appears to confirm this last opinion; but notwithstanding the essays of Goodwyn, it requires many farther experiments, as does every thing relating in general to the three great functions of animals with cold blood.

ARTICLE XIII.

OF THE INFLUENCE WHICH THE DEATH OF THE BRAIN HAS UPON GENERAL DEATH.

UPON a recapitulation of all that has been said in the preceding articles, it will be very easy, I trust, to form a correct idea of the manner in which the phenomena of general death which commences in the brain take place. The following is the series:

1st, An annihilation of cerebral action. 2d, A sudden cessation of the sensations and voluntary locomotion. 3d, A simultaneous paralysis of the diaphragm and intercostal muscles. 4th, An interruption of the mechanical phenomena of respiration and consequently of the voice. 5th, The same with respect to the chymical phenomena. 6th, The passage of black blood into the system of red blood. 7th, An abatement of the circulation by the contact of this blood upon the heart and arteries, and by the absolute immobility of all the parts, particularly of the breast. 8th, The death of the heart and cessation of general circulation. 9th, The simultaneous interruption of organic life, particularly in those parts accustomed to receive red blood. 10th, The abolition of animal heat which is the product of all the functions. And lastly, The consequent termination of the action of the white organs, which are slower in dying than all the other parts, because the juices which support them are more independent of the great circulation.

Though in this kind of death, as in the two preceding, the functions are suddenly annihilated, yet many vital properties remain in the parts for a certain time: organic sensibility and contractibility, for example, are very manifest

in the muscles of the two lives; galvanic susceptibility remains to a considerable degree in those of animal life.

This permanence of organic properties, is nearly the same in all cases; the only circumstance which can create a difference, is the more or less tardy manner in which the animal has perished. The more rapid death has been, the more powerful is the contractibility, and the longer is it in disappearing. On the contrary, the more slowly the organs have ceased their functions, the less susceptible is this property of being excited to action.

In the duration of the phenomena which precede general death by that of the brain, *cæteris paribus*, experiments upon contractibility always present nearly the same result, because the connexion of these phenomena and the immediate cause which produces them also remain always nearly the same. Apoplexy, commotion, inflammation, violent compression of the brain, a division of the spinal marrow under the occipital, compression by a luxation of the vertebræ, &c. are remote causes very different in themselves, but all which produce a uniform próximate cause.

It is not the same in asphixia by the different gases, a disease after the termination of which the state of contractibility varies very much, though often the duration of the phenomena of death has been similar. This, as we have seen, depends upon the diversity of the nature of the poisons, which are introduced by the air-passages, and carried by the circulation to the different organs, which they affect more or less feebly and directly.

The state of the lungs varies considerably in the bodies of those whose death has had its principle in the brain. Sometimes replete, and sometimes void of blood, it generally points out, acccording to these two states, whether the cessation of the functions has been gradual, and whether consequently the blow has not suddenly destroyed the

cerebral action, or whether general death has been sudden. In those subjects brought to my amphitheatre, with wounds of the head, bloody effusions of the brain, the effect of apoplexy, &c. I have scarcely found two with the lungs in the same disposition. The state of repletion and lividity of the external surfaces, of the skin of the head, neck, &c. was equally variable.

Death, which succeeds to varous diseases, commences much more rarely in the brain than in the lungs. Nevertheless, in some paroxysms of acute fevers, the blood carried with violence to the brain, sometimes destroys its life. The patient has a delirium, as it is commonly called. If this delirium is raised to the highest degree it proves mortal, and then the series of phenomena is the same as that in sudden deaths of which we have just spoken.

There is a great number of cases besides that of acute fevers, in which the commencement of death may be in the brain, though this organ may not be the seat of the disease.

It is in these cases, particularly, that the state of plenitude or vacuity of the lungs varies so much. In general this state furnishes no hint as to the disease of which the patient has died; it merely indicates the manner in which the functions have ceased in the last moments of existence.

THE END.

ERRATUM.

In page 8, at the head of the Section, for *Organic life*, the reader will please to read *Animal life*.